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OF THE RELIABILITY OF A TWO-WAY HYDRAULIC CYLINDER

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ABSTRACT

A hydraulic cylinder is a volumetric hydraulic motor that converts the energy of the fluid flow into various types of movement of the output link. The use of volumetric hydraulic drives with a hydraulic cylinder working element in all possible fields of industry does not require high capacities. One of the advantages is the ease of operation and overload protection. There are also disadvantages. For example, the hydraulic cylinder depends on the working fluid and in case of contamination it may fail, and therefore the reliability of the hydraulic cylinder decreases. In order to protect hydraulic cylinders from moisture and dirt entering them, as well as to increase their reliability, seals with dirt-removing rings are provided. When assembling or disassembling hydraulic cylinders, important conditions must be taken into account, since failure to comply with these conditions can lead to a defect. Considerable efforts have been made to the parts, so some manual operations are excluded when assembling and disassembling hydraulic cylinders. The reliability of the hydraulic cylinder and, consequently, its reliability are the main topic of the study. Hydraulic cylinders can be of translational action and rotary action. Translational ones include: piston, plunger, telescopic. Reciprocating, in turn, can be one-sided and two-sided. If it is required to create an effort in only one direction, a one-way hydraulic cylinder is designed. At the beginning of the work, a diagram of a volumetric hydraulic drive and its principle of operation is presented. Special attention is paid to assessing the reliability of the hydraulic cylinder. In conclusion, the results of the analyses and the conclusions of the calculations are given. The change in the reliability of the hydraulic cylinder over time was also indicated and the reasons for this change were named.
Keywords: Reliability, hydraulic cylinder, hydraulic drive, failure, reliability assessment, pipeline, pump, valve, operating time, hydraulic distributor.

The purpose of the work. The study of the reliability of the hydraulic cylinder, and therefore, as a result of the study, indicate the dependence of reliability on operating time, operating conditions and quality of maintenance.

The scheme of the volumetric hydraulic drive and its principle of operation. Figure 1. shows the hydraulic drive diagram.

The volumetric pump 2, sucking the liquid from the hydraulic tank 6, pumps it through the hydraulic drive 4, passing through the electric hydraulic distributor 14, enters the piston cavity of the hydraulic cylinder 15, which in turn makes a straight stroke. The working fluid located in the cavity of the stem flows into the drain pipeline 5 through the electric hydraulic distributor 14. To avoid the occurrence of high pressure in the pipeline, a pressure reducing valve was installed by-pass, which, under excessive pressure, directs the working fluid back into the suction pipeline. For the reverse stroke of the hydraulic cylinder 15, it is required to change the position of the electric

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hydraulic distributor 14. When changing the position, the working fluid pumped by the pump 2, passing through the electric hydraulic distributor 14, enters the cavity of the rod, while creating a retracting force at which the piston and the rod enter into the hydraulic cylinder 15. In parallel with the filling of the stem cavity, the volume of the piston cavity decreases, which leads to the displacement of the working fluid from this cavity. The liquid flowing out of the piston cavity, through the electric hydraulic distributor 14, enters the drain line 5, and then into the hydraulic tank 6.

To achieve a stable fluid flow, the use of a pressure compensation device is required. When pumping the working fluid at the pump 2, the sensor 10 measures the pulsation of the fluid flow. When a positive pulsation occurs, when the pressure is greater relative to the average value. The ripple sensor converts the signal, sends it to the primary signal amplifier 11, then the signal enters the processing unit 13, where the signal is processed. After processing, the signal is sent to the secondary signal amplifier, where it is redirected to the electric hydraulic distributor 16. Under the influence of the signal, the electric hydraulic distributor 16 changes its position and connects the pressure pipeline 4, with the drain line 5. To stabilize the pressure reduction of the discharge pipeline, a hydraulic accumulator 17 with a weak pressure connected to the drain line 5 is used.

When a positive pulsation of the working fluid occurs, the pulsation sensor 10 converts the signal, sends it to the signal amplifier 11, then the signal gets into the processing unit 13, in which, depending on the signal, the signal output from the secondary signal amplifier 12 will be selected.

If the pressure is low and the pulsation is negative, then the measuring sensor 10 sends a signal to the primary amplifier 11, the signal is amplified and sent to the signal processing unit 13, after which it is determined where to send the signal from the box 12, to the upper or lower electric hydraulic distributor, after which the signal is sent from 12 to the electric hydraulic distributor 9. In this position of the electric hydraulic distributor 9, the line connecting the pressure pipeline 5 and the accumulator 7 opens, the damping of negative pulsation occurs due to excess pressure in the accumulator, which is created by the pump 2 through the check valve 8.

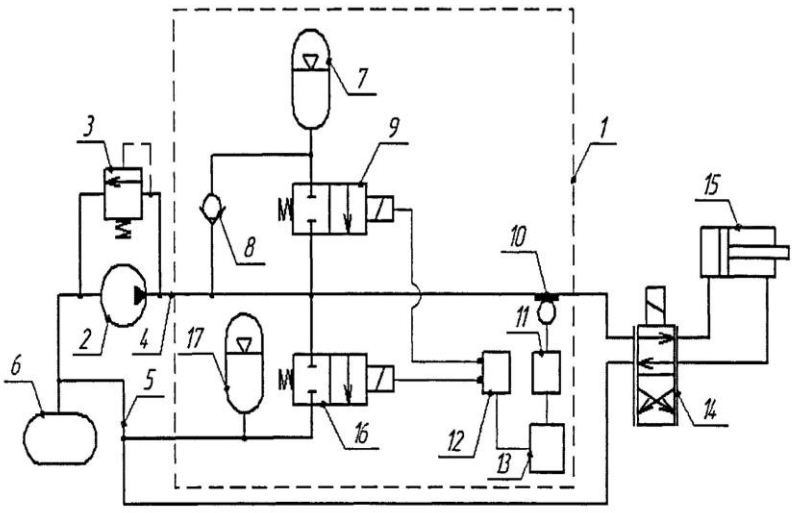

Figure 1: Diagram of a volumetric hydraulic drive:

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1 - control system; 2 - volumetric pump; 3 - pressure reducing valve; 4- discharge pipeline; 5 - drain line; 6 - hydraulic tank; 7 - accumulator; 8 - check valve; 9 - electric hydraulic distributor; 10 - pulsation sensor; 11 - primary signal amplifier; 12 - secondary signal amplifier; 13 - processing unit; 14 - two-position electric hydraulic distributor; 15 hydraulic cylinder; 16 - electric hydraulic distributor; 17 - accumulator.

Evaluation of the reliability of the hydraulic cylinder.

To assess the reliability of the hydraulic drive, we will take the maximum operating time.

It is assumed that periodic loading of the pump can increase its resource up to 2 times. It follows that the operating time of the pump for failure will be 5000·1.5 = 7500 hours, and the failure rate $\lambda' = 1/7500 \approx 133 \cdot 10^{-6}$ h^{-1}.

Each subsystem (contour) consists of the following elements k_i: with known values of the intensity λ' of their failures.

Pump and battery circuit ($k_1 = 9$). Maximum failure rate $\lambda''_1 = 828 \cdot 10^{-6}$ h^{-1}.

Power circuit ($k_2 = 1$): hydraulic cylinder $\lambda''_2 = 154 \cdot 10^{-6}$ h^{-1}

Let's take the operating time in 1000 hours.

Calculation of the quantitative value of the reliability of each circuit:

$$P'(k_1) = e^{-\lambda''_1 T} = \frac{1}{2.718^{0,000828-1000}} = 0,33 \quad (1)$$

$$P'(k_2) = e^{-\lambda''_2 T} = \frac{1}{2.718^{0,000154-1000}} = 0,463 \quad (2)$$

The probability of trouble-free operation of the mechanism within 1000 hours is:

$$P'(t) = P'(k_1)P'(k_2) = 0,33 \cdot 0,463 = 0,15 \quad (3)$$

Now we will find the operating time of the lift in 5000 hours in order to understand how the probability of trouble-free operation will change with an increase in the operating time of the hydraulic mechanism. Calculation of the quantitative value of the reliability of each circuit:

$$P'(k_1) = e^{-\lambda''_1 T} = \frac{1}{2.718^{0,000828-5000}} = 0,063 \quad (4)$$

$$P'(k_2) = e^{-\lambda''_2 T} = \frac{1}{2.718^{0,000154-5000}} = 0,34 \quad (5)$$

The probability of failure-free operation of the mechanism for 5000 hours is:

$$P'(t) = P'(k_1)P'(k_2) = 0,63 \cdot 0,34 = 0,021 \quad (6)$$

Conclusion. After the research done, it can be concluded that the reliability of the hydraulic mechanism directly depends on the operating time, operating conditions and quality of maintenance. If we increase the operating time by 5 times, therefore the reliability will decrease by 7 times. The decrease in reliability is due to the fact that the hydraulic drive elements wear out over time and can lead to failures and breakdowns.

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ИССЛЕДОВАНИЕ НАДЕЖНОСТИ ГИДРОЦИЛИНДРА ДВУХСТОРОННЕГО ДЕЙСТВИЯ.

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РЕЗЮМЕ

Гидроцилиндр - это объемный гидродвигатель, который преобразует энергию потока жидкости в различные виды движения выходного звена. Использование объемных гидроприводов с рабочим элементом гидроцилиндром во всех возможных сферах промышленности не требует высоких мощностей. Одним из преимуществ является простота работы и предохранение от перегрузок. Также существуют и недостатки. Например, гидроцилиндр зависит от рабочей жидкости и в случае её загрязнения могут выйти из строя, в связи с этим уменьшается и надежность гидроцилиндра. Для того чтобы предохранить гидроцилиндры от попадания в них влаги и грязи, а также увеличить их надежность, предусматривают уплотнения с грязесъемными кольцами. При сборке или разборке гидроцилиндров нужно учитывать немаловажные условия, т.к. при несоблюдении данных условий может привести к дефекту. К деталям приложены значительные усилия, поэтому при сборке разборке гидроцилиндров исключены некоторые операции вручную. Безотказность работы гидроцилиндра и, следовательно, его надёжность являются главной темой исследования. Гидроцилиндры могут быть поступательного действия и поворотного действия. К поступательным относятся: поршневые, плунжерные, телескопические. Поршневые в свою очередь могут быть одностороннего и двухстороннего действия. При требовании создания усилия только в одном направлении, проектируется гидроцилиндр одностороннего действия. В начале работе представлена схема объемного гидропривода и его принцип действия. Особое внимание уделено оценке надежности гидроцилиндра. В заключение приводятся итоги анализов и выводы по расчетам. Также было указано изменение надежности гидроцилиндра с течением времени и названы причины этого изменения.

Ключевые слова. Надежность, гидроцилиндр, гидропривод, отказ, оценка надежности, трубопровод, насос, клапан, наработка, гидрораспределитель.

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İKİTƏSİRLİ HİDRAVLİK SİLİNDRİN ETİBARLILIĞININ TƏDQİQİ

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XÜLASƏ

Hidravlik silindr maye axının enerjisini çıxış bəndinin hərəkətinin müxtəlif növlərinə çevirən hidravlik muhərrikdir. İşçi elementi hidrosilindr olan həcmi hidravlik intiqal sənayenin bütün mümkün sahələrində istifadəsi yüksək güc tələb etmir. Üstünlüklərdən biri də onun istismarının sadəliyi və həddindən artıq yüklənmədən qorunmasıdır. Həmçinin, çatışmayan cəhətləri də var. Məsələn, hidravlik silindr işçi mayedən, xüsusilə onun çirklənməsi baş verdikdə, onun sıradan çıxmasına və nəticədə hidrosilindrin etibarlılığının aşağı düşməsinə səbəb olur. Hidrosilindrin nəmdən və kirdən qorumaq, həmçinin, etibarlılığının artırılması məqsədilə, palçıqtəmizləyici (kirtəmizləyici) həlqələri olan kipləndiricilərin tətbiqi nəzərdə tutulur. Hidrosilindrlərin yığılıb sökülməsində bir sıra mühüm şərtlərin nəzərə alınması vacibdir, beləki, bu şərtlərin yerinə yetirilməməsi ciddi qüsurlara səbəb olur. Detallar əhəmiyyətli dərəcədə qüvvəyə məruz qaldığından hidrosilindrin yığılıb - sökülməsi zamanı bir qisim əməliyyatların əl ilə icrası istisna olunur. Hidrosilindrin imtinasiz işləməsi və müvafiq olaraq onun etibarlılığı - tədqiqat işinin əsas mövzusudur. Hidrosilindrlər irəli və fırlanan (dönən) hərəkətli növdə olurlar. İrəli hərəkətli növə aiddir: porsenli, plunjerli, teleskopik silindrlər. Porşenli hidrosilindrlər öz növbəsində, bir təsirli və iki təsirli olur. Yaranan qüvvənin təsiri bir istiqamətdə tələb olunursa, hidrosilindr bir təsirli layihələndirilir. Təqdim olunan işdə həcmi hidravlik intiqalin sxemi və onun iş prinsipi təqdim olunur. İşdə hidravlik silindrin etibarlılığının qiymətləndirilməsinə xüsusi diqqət yetirilir. Sonda, nəticələrin yekun analizi və hesablamalara dair nəticələrin təhlili verilir. Həmçinin, hidrosilindrin etibarlılığının dəyişməsinin zamandan asılılığı qeyd olunaraq onun dəyişmə səbəbləri açıqlanır.

Açar sözlər: Etibarlıq, hidravlik silindr, hidravlik muhərrik, imtina, etibarlığın qiymətləndirilməsi, boru kəməri, nasos, klapan, işləmə, hidravlik paylayıcı.

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CALCULATION OF THE MAIN ELEMENTS OF THE ROPE-PULLEY DRIVE OF A DOWNHOLE ROD PUMPING UNIT

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ABSTRACT

The goal of minimizing oil production costs is becoming increasingly crucial in current oil production settings, particularly during the operation of oil fields in the final phases of development and the ever-expanding commissioning of difficult-to-recover hydrocarbon reserves. Oil production practice has shown, lengthening the length of the steel pumping plant's loop needs a lower frequency of rolling, which extends the life of the well equipment and enhances pumping installation performance. The engine's weight and cost increase as the drive lengthens. The necessary characteristics made it impossible to build long-stroke balancing drives. One of the ways to solve this problem is the use of long-stroke unbalanced sucker-rod pump drives as part of pumping units, which will significantly reduce energy consumption for oil production and, accordingly, reduce the cost. The presented article shows the prospects of using unbalanced drives of sucker-rod pumping units in the operation of wells by mechanized method.
The kinematic-power diagram of the drive of the downhole rod pumping unit is shown.
A method for calculating the acting forces is given. To calculate the strength of the structure being developed, it is important to determine the change in the force acting on the suspension point of the rods. In order to carry out repair work, the goal was set to further improve the unbalanced drive WRPU (well rod pump unit). For this, a scheme was proposed for changing the fixed guide pulley to a movable one, installed on the base with the possibility of its rotation. The proposed design of the rotary pulley makes it possible to free up space above the wellhead.
Keywords: unbalanced drive, long stroke, swivel pulley, beamless drive of pumping unit, rod suspension point, crank-pulley converting mechanism.

The mechanized method of oil production using a downhole pumping unit is widely used in the operation of wells. Downhole rod pumping units, a simple device in terms of design, mastered in the early 1920s, has become the most common method of oil production in the world. Service efficiency and reliability of well pumps, high efficiency, flexibility in regulating fluid selection from different depths, the possibility of their application in complex geological conditions and a number of other advantages have brought this method to a leading place in the oil industry. Traditional balancing devices are extremely reliable due to continuous development. There was a requirement for the usage and enhancement of various types of drives. Thus, in connection with the transition of oil fields to the late stage of development, as well as the operation of wells of the so-called "problem" fund, the reduction of oil production costs by increasing the coefficient of utility of the pump plant as a whole becomes relevant, and also increases the inter-repair period of the wells by ensuring better operating conditions of the equipment.

As oil production practice has demonstrated, increasing the length of the loop of the steel pumping plant necessitates a lower frequency of rolling, which extends the life of the well equipment and improves the pumping installation's performance. The weight and expense of the engine rise as the length of the drive grows. The specified features prevented the construction of long-stroke balancing drives. This resulted in the creation of a new type of well drive - unbalanced long-stroke pumps. The prospect of exploitation of these installations under normal technological conditions as well as in the production of high-viscous and high-carbonated oil, as well as the ability to control the length of the flow of the plunge over a wide range, enabled the oil production process to be modernized.

The closest equivalent is a rolling machine, in which the balancer and connecting rod are replaced by a rope transported through the slope, with one end attached to the curve and the other with the mouth rod. The curves of the unbalanced rolling machines have a V-shaped shape that ensures the balancing of the drive. The unbalance machine allows you to increase the stroke length of the wellhead rod. It works on a symmetrical cycle, unlike the balancing RM, and enhances the working conditions of the machine reducer nodes as well as the columns of pump bars. Unbalanced machines are produced serial under codes UMM3-1,8-700; UMM6-3-2500; UMM12-5-800. The benefit of these drives is that they reduce total drive size, improve maintenance conditions, and reduce metal intensity, hence enhancing transportability and installation capacity.

When designing and operating well pump installations, it is necessary to know the patterns of change of S movements, υ speeds and accelerations of the W point of suspension of the bar, which affect the performance of installation and load on the equipment.

Figure 1 shows the design of the UMM type pumping unit developed at ARDIPE, in which the balancer is replaced by a conventional non-differential pulley.

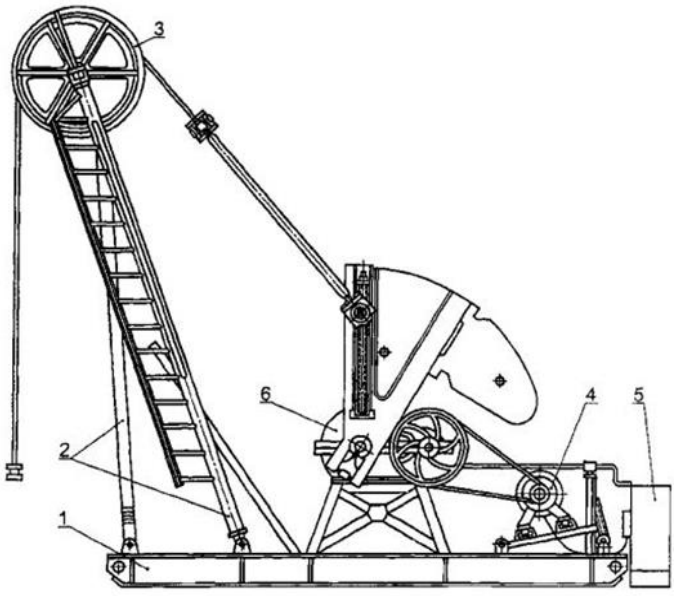

Figure 1: Unbalanced rocking machine UMM:
1 – frame; 2 – rack; 3 – pulley; 4 – drive motor; 5 – engine control panel; 6 – gearbox

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The total travel length of the driven end of the rope is equal to two crank diameters. The pulley is located on the rack and makes several two-way revolutions per crank revolution. The deflected design of the rack is very convenient for downhole repair work. The arc head of conventional pumping units is designed to be hinged, swivel or removable, due to unfavorable moments from the standpoint of safety. The disadvantage of the design is the complexity of the configuration of the crank.

Let's calculate the main elements of the rope-pulley drive WRPU. Figure 2 shows the kinematic-power diagram of the drive of the downhole rod pumping unit.

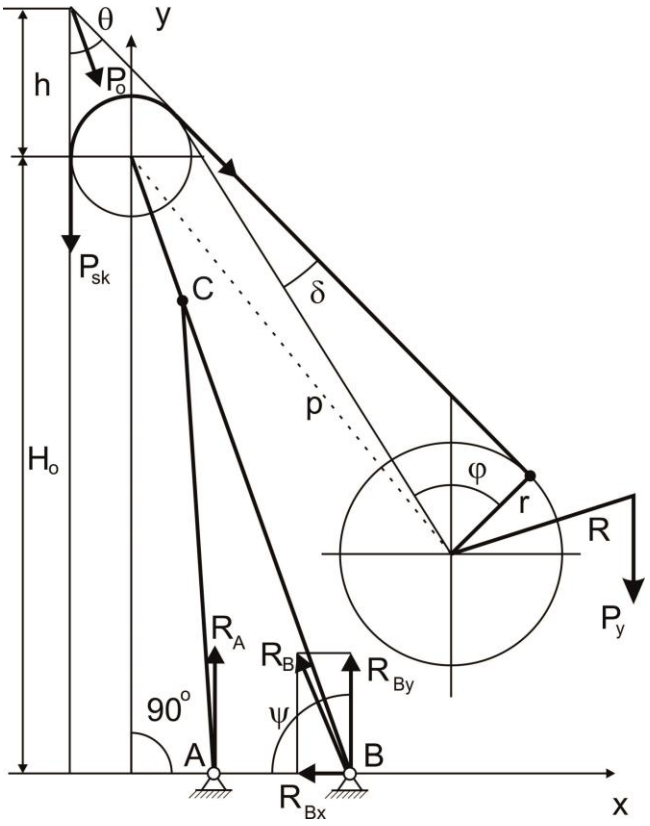

Figure 2: Kinematic-power diagram of the drive of a downhole rod pumping unit

Let's calculate the acting forces. To simplify the calculation, the following assumptions are possible:

1) Minor friction losses in rope pulley supports are not taken into account. As a consequence, the forces acting on the connecting rods will be equal to the force at the rods' suspension point, and the resultant of these forces (P_o) will be applied to the rope pulley's axis.

2) The shaft of the AC stand is taken vertically oriented (position of the AC, Figure 2), which simplifies the determination of the support reactions of the stand (point B).

This raises the value of the force on the shaft and the bending moment of the stand's leg. Since the value of the actual force and the bending moment is smaller compared to those taken into

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calculation in such an interrogation, the actual strength reserves will be greater than those obtained by the calculation.

To calculate the strength of the design being developed, it is important to determine the change in the force acting on the suspension point of the rods. As a rule, at the maximum depth of suspension of the pump, a three-stage column of pump rods is selected with the lengths of each column, starting from the lower stage - l_1, l_2, l_3 and corresponding diameters d_{r1}, d_{r2}, d_{r3}.

The average sectional area of the rods is determined by the formula:

$$f_r = \frac{1}{\frac{l_1}{f_{r1}} + \frac{l_2}{f_{r3}} + \frac{l_3}{f_{r3}}}$$

where f_{r1}, f_{r2}, f_{r3} – is the cross-sectional area of the rods of the corresponding stage.

The average weight per linear meter of rods is determined as follows:

-in liquid $q_r = l_1 q_{r1} + l_2 q_{r2} + l_3 q_{r3}$

-in the air $q'_r = l_1 q'_{r1} + l_2 q'_{r2} + l_3 q'_{r3}$

During the operation of the pumping unit, the load on the rope pulley and on all components of the mechanism varies depending on the direction of movement of the plunger.

The weight of the rod string is calculated using the following formulas:

-in liquid $P_r = q_r H$;

-in the air $P'_r = q'_r H$.

The value of the initial deformation of rods and pipes is determined by the formula:

$$\Delta S = \frac{P_L H}{E}\left(\frac{1}{f_r} - \frac{1}{f_т}\right),$$

$$P_L = 0{,}1\, F_p\, \gamma_L\, H,$$

$$F_p = \frac{\pi d_p^2}{4}$$

where F_p – is the cross-sectional area of the pump; f_T – is the cross-sectional area of the tube; γ_L – specific gravity of liquid $\gamma_L = 9$ kN/m^3; d_p – is the diameter of the pump.

$$\lambda = \frac{\Delta S}{S_o}$$

The amount of relative deformation is determined according to the formula:

The relative acceleration is determined by the formula:

a) at the beginning of the upward : W^{OB}_{OT}

b) at the end of the period of initial deformation during the upward stroke : W^{B}_{OT}

c) at the beginning of the downward : W^{OB}_{OT}

d) at the end of the period of initial deformation during the downward stroke : W^{OB}_{OT}

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The absolute acceleration is determined by the formula:

a) at the beginning of the upward : W^{B}_{O}

b) at the end of the period of initial deformation during the upward stroke

$$W^{B}_{\lambda} = \omega^2 S_0 W^{B}_{ON_\lambda}$$

c) at the beginning of the downstroke $W^{H}_{0} = \omega^2 S_0 W^{OH}_{ON_\lambda}$

d) at the end of the initial deformation period : $W^{H}_{\lambda} = \omega^2 S_0 W^{H}_{ON_\lambda}$

To calculate the change in force Psk for one cycle of cranking, create a theoretical dynamometer chart for the next six points (without taking into account the vibration load).

1. At the beginning of the upstroke: $$P_A = P_r + P'_r \frac{W^{B}_{o}}{g}$$

2. At the end of the period of initial deformation of pipes and rods during the upward stroke:

$$P_V = P_r + P_L + (1-\psi)\frac{P'_r}{g} W^{B}_{\lambda}; \qquad \psi = \frac{f_{tp}}{(f_ш + f_{tp})}$$

3. At the beginning of the downstroke:

$$P_B = P_r + P_L + (1-m)\frac{P'_r}{g} W^{H}_{0}; \qquad m = \frac{(F_p - f_r)^2}{8{,}25 f_r (f_T - f_r)}$$

4. At the end of the period of initial deformation of the rods and pipes during the downward stroke:

$$P_c = P_r + \left(1 - \frac{\psi}{3}\right)\frac{P_r}{3} W^{H}_{\lambda}$$

5. Maximum force at the suspension point of the rods:

$$P_{max} = P_r + P_L + K_v \omega S_o V^{B}_{\lambda} + K_a H \omega^2 S_o W^{B}_{\lambda}$$

K_v and K_a – dynamic coefficients: $K_v = f_r \frac{E}{a}\psi$; $K_a = 0{,}99984(1 - \Psi/2) f_ш$

where a – is the speed of sound in the rods.

6. Minimum force at the suspension point of the rods:

$$P_{min} = P_r + K_v \omega S_o V^{H}_{\lambda} + K_a H \omega^2 S_o W^{H}_{\lambda}$$

According to the calculated six points, a theoretical dynamogram of efforts in the RSP (rod suspension point) is constructed depending on the stroke length for turning the crank by 360°. In accordance with the data of this dynamometer, the forces acting on the nodes of the unbalanced

drive are determined, as well as the values of P_{sk}, θ and P_o depending on the angle φ of the crank rotation. The angle θ is found graphically (Fig.3).
The resultant force P_o is determined from the dependence:

$$P_o = 2P_{sk}\cos\frac{\theta}{2}$$

Resistance reactions are determined as follows.
The AC bevel (see Fig. 2) is pivotally connected at both ends. Therefore, the reaction force in support A coincides with the direction of the slope and, based on the second assumption, is directed vertically. The magnitude of the reaction force of the support A is calculated by the formula:

$$R_A = P_{sk}\left(3\cos^2\frac{\theta}{2} - 4{,}76\sin\theta\right)$$

The value of the reference reaction R_B is determined according to the formula:

$$R_B = P_{sk}\sqrt{\left(4{,}76\sin\theta - \cos^2\frac{\theta}{2}\right) + \sin^2\theta}$$

The direction of R_B is determined by the angle γ enclosed between the positive direction of R_B and the negative direction of the X axis (Fig.2).The direction of this angle γ is equal to:

$$\gamma = \operatorname{arctg}\left(4{,}76 - 0{,}5\operatorname{Ctg}\frac{\theta}{2}\right)$$

Determination of the force on the rods of the rack (Fig.3).
The force in the direction of the leg of the stance is defined as the projection of P_o on the direction of the leg

$$P_H = P_o\sin\left(\psi + \frac{\theta}{2}\right);$$

$$\psi = 72^o30'$$

The force bending the leg of the stand P_q is equal to:

$$P_q = P_o\left[\operatorname{Cos}\left(\psi + \frac{\theta}{2}\right)\right]$$

The force acting on the connecting rod P_{cr}, by virtue of the accepted assumption, is taken equal to the force at the point of suspension of the rods. Since there are two connecting rods, then:
$P_{cr} = 0{,}5\ P_{sk}$.

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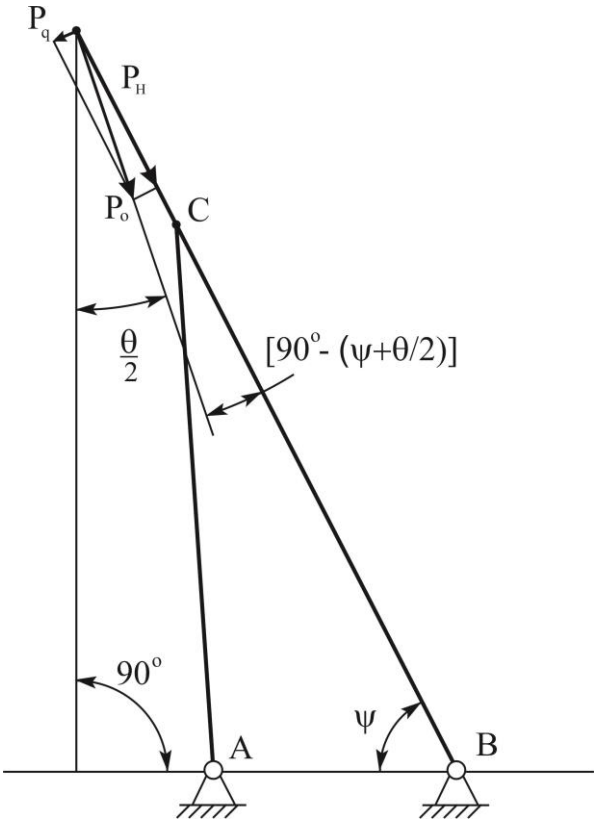

Figure 3: Scheme for determining the angle θ

For the possibility of long-stroke operation, it is proposed to increase the height of the unbalanced drive rack, fix the rack on the frame without the possibility of deviation from the wellhead, and install the pulley on an eccentrically located adjustable base 2 with the possibility of turning it through the threaded fastening 3, fixed top shelf rack (Fig.4). A scheme was proposed for changing the fixed guide pulley to a movable one. The design is a guide block 1 mounted on an adjustable base 2 with the possibility of its rotation.

PROPOSED NOVELTY

In order to facilitate repair and installation work, engineers pursue the goal of further improvement of ground drives BRPU. Taking into account all the advantages of the unbalanced rope-pulley drive of the DRP, the following idea was proposed. In existing unbalance drives, as a rule, the pulley is installed above the wellhead and, during repair work in the well, interferes with the movement of the traveling block of the lifting unit. To free up space above the mouth during repair work, either reject the rack with a pulley, either the entire drive is removed, or the balancer is made shaped with different arc radii, and to free the wellhead, the balancer is turned 180°.

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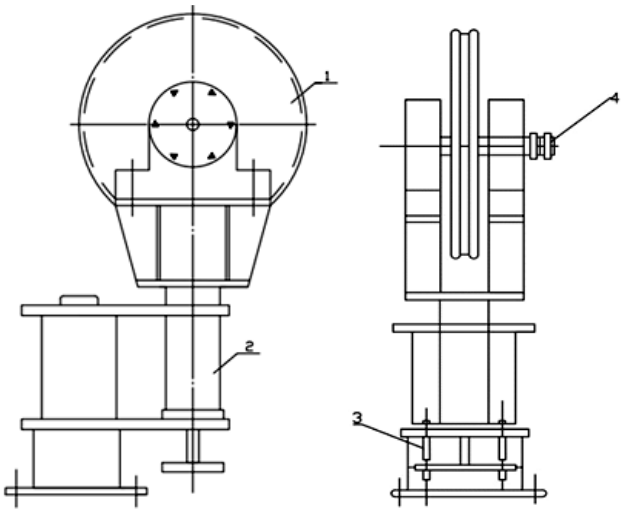

Figure 4: Swivel pulley design
1 – guide block, 2 – adjustable base, 3,4 – threaded connection

Thus, the analysis of the application of kinematic-power characteristics showed the promise of unbalanced rope-pulley drives. With an increase in the stroke length, it becomes necessary to reduce the number of double strokes, which can be achieved by introducing an additional chain drive. By reducing the number of double strokes, the service life of the submersible pump is increased. When choosing the number of strokes of the pump plunger, it is necessary to take into account the fact that the downward stroke is carried out due to gravity, which depends on the free fall acceleration of the rod string. The proposed design of a swivel pulley on an adjustable base makes it possible to free up the over hole space in order to facilitate repair work.

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РАСЧЕТ ОСНОВНЫХ ЭЛЕМЕНТОВ КАНАТНО-ШКИВНОГО ПРИВОДА СКВАЖИННОЙ ШТАНГОВОЙ НАСОСНОЙ УСТАНОВКИ

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РЕЗЮМЕ

В современных условиях нефтедобычи, особенно при эксплуатации нефтяных месторождений на поздних стадиях разработки и вводом в разработку трудно извлекаемых запасов углеводородного сырья, все более важной становится задача – снижение затрат на добычу нефти. Как показала практика, увеличение длины хода штанговой насосной установки требует меньшей частоты качаний, что повышает срок службы скважинного оборудования и КПД насосной установки. Однако с увеличением длины хода, соответственно, увеличиваются масса и стоимость привода. Указанные особенности препятствовали конструированию длинноходовых приводов балансирного типа. Одним из путей решения этой проблемы является использование длинноходовых безбалансирных приводов штангового насоса, позволяющих снизить энергопотребление для добычи нефти и, соответственно, себестоимость. В представленной статье показана перспективность применения безбалансирных приводов штанговых насосных установок при эксплуатации скважин механизированным способом. Показана кинематико-силовая схема привода скважинной штанговой насосной установки. Дана методика расчета действующих сил. Чтобы рассчитать прочность разрабатываемой конструкции, важно определить изменение усилия, действующего на точку подвеса штанг. С целью проведения ремонтных работ, была поставлена цель дальнейшего усовершенствования безбалансирного привода СШНУ. Для этого была предложена схема изменения неподвижного направляющего шкива на подвижный, установленный на основании с возможностью его поворота. Предложенная конструкция поворотного шкива дает возможность освобождения пространства над устьем скважины.

Ключевые слова: безбалансирный привод, длинноходовой, поворотный шкив, точка подвеса штанг, кривошипно-шкивной преобразующий механизм.

ŞTANQLI QUYU NASOS QURĞUSUNUN İP-KASNAQ SÜRÜCÜSÜNÜN ƏSAS ELEMENTLƏRİNİN HESABLANMASI

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XÜLASƏ

Müasir neft hasilatı şəraitində, xüsusən neft yataqlarının işlənməsinin son mərhələlərində istismarı və çətin bərpa olunan karbohidrogen ehtiyatlarının işlənməsini daxil edilməsi zamanı daha vacib məsələdən biri – neft hasilatı xərclərini azaltmaqdır. Təcrübə göstərdiyi kimi, quyu ştanqlı nasos qurğusunun gediş yolu uzunluğunun artması daha az yellənmə tezliyi tələb edir ki, bu da quyu avadanlığının xidmət müddətini və nasos qurğusunun səmərəliliyini artırır. Bununla birlikdə, gediş yolu uzunluğunun artması ilə intiqalın kütləsi və dəyəri müvafiq olaraq artır. Bu xüsusiyyətlər taraz tipli uzun gedişli intiqalların konstruksiya edilməsinə mane olurdu. Bu

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problemi həll etməyin yollarından biri, neft istehsalı üçün enerji istehlakını və müvafiq olaraq maya dəyərini azaltmağa imkan verən uzun gedişli tarazsız ştanqlı nasos intiqalların istifadəsidir. Təqdim olunan məqalədə quyuların mexanikləşdirilmiş üsulla istismarı zamanı ştanqlı nasos qurğularının tarazsız intiqalların istifadənin perspektivləri göstərilir. Ştanqlı quyu nasos qurğusunun kinematik-güc intiqalın sxemi göstərilir. Təsir edən qüvvələrin hesablanma metodikası verilir. İşlənən konstruksiyasınımöhkəmliyə hesablamaq üçün ştanqların asqı nöqtəsinə təsir edən qüvvənin dəyişməsini müəyyən etmək vacibdir. Təmir işini aparmaq üçün QŞNQ tarazsız intiqalı daha da təkmilləşdirmək məqsədi qoyulmuşdur. Bunun üçün fırlanma imkanı ilə əsasda quraşdırılmış sabit istiqamətləndırıcı qasnağının dönən qaznağa dəyişdirilməsi sxemi təklif edilmişdir. Dönən qasnağın təklif olunan konstruksiyası quyu ağzinin üst fəsanı boşaldmağa imkan verir.

Açar sözlər: tarazsız intiqal, uzun gedişli, dönən qasnaq, ştanqların asqı nöqtəsi, tarazsız ştanqlı nasos, çarxqolu-qaznaqlı çevirici mexanizmi.

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AVOID DAMAGE TO LOADER CRANE COMPONENTS A STUDY OF CONCENTRATION

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ABSTRACT

Crane parts work with non-stationary variable loads. The hypothesis of linear summation of fatigue damage during non-stationary cyclic tests is not confirmed. Under the influence of alternating stresses, a process of gradual accumulation of damage occurs, which leads to the formation of cracks of various nature, which gradually increase, forming macroscopic values.
The work is devoted to the study of stress concentratıons leading to damage to crane parts. The results of the research revealed that the set of possible methods for non-stationary modes is not considered valid and was not fully justified from a physical point of view. From a physical point of view, the direction of the ongoing processes is determined by the method of lowering the curtain. However, this method itself requires further development and accuracy. The application of the Dahlgren method is a manner that inaccurately describes the process and its application is incorrect. When choosing materials that work for fatigue in non-stationary modes, along with other characteristics, it is necessary to take into account the criterion of sensitivity to loads.
Keywords: step loading, hypothesis, damage, secondary fatigue curves, experiment.

Introductıon. Fatigue resistance under the influence of fatigue stresses is determined by the accumulation of fatigue damage. Fatigue damage accumulation occurs in two stages: pre-crack initiation and crack growth [1,2,3,4].

Statement of the ıssue:

At the beginning of the first stage under the influence of alternating stresses, a gradual accumulation of fatigue damage occurs. The first stage accounts for 70–90% of the total fatigue breakdown process. As a result of the gradual accumulation of fatigue damage, the properties of the material change, submicroscopic cracks are formed, and their further growth leads to the formation of microscopic cracks.
The first stage of the fatigue process is related to the presence of tangential stresses and leads to the formation of cracks in the slip lines. After the formation of cracks, this process is further developed as a result of the effect of normal stresses generated in tension [2]. Therefore, it is of great importance to study the regularities of damage accumulation in the first stage.
A large number of scientific works have been devoted to the study of damage accumulation laws in non-stationary loads [5,6,7,8,9].

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The idea of fatigue damage summation according to a linear law was proposed by Palmgren to account for the contact fatigue of rolling bearings and is expressed as follows:

$$\sum \frac{n_i}{N_i} = 1, \tag{1}$$

where $n_i - \sigma_{\alpha i}$ the number of cycles corresponding to the amplitude voltage; $N_i - \sigma_{\alpha i}$ is the number of cycles in the stress-amplitude fatigue curve.

PROBLEM SOLVING METHOD:

Mayner [10] believes that energy dissipation is proportional to the number of cycles. If the energy during one cycle $\alpha_i = \frac{A}{N_i}$ decreases to , then the total energy during dissipation takes the following value:

$$\sum \frac{n_i}{N_i} = A\,, \tag{2}$$

or

$$\sum \frac{n_i}{N_i} = 1$$

However, Miner's idea that the energy is constant over a cycle does not prove itself in the endurance limit zone and below.

In his works, Weibul [11,12] puts forward the assumption that damage increases equally for each cycle.

$$D = R \cdot n \tag{3}$$

Damage Accumulation Rate:

(4)

According to Freudenthal [13], summation of damages is expressed in the form of an upper function. In this work, the probabilities of the formation of sources of dispersion were considered and the probabilities of working of the samples were put forward. The damage summation is expressed as a super function as follows:

$$D = \sum \left(\frac{n_i'}{N_i'} \right)^{\rho(\sigma_i)} \tag{5}$$

$$\frac{n_i'}{N_i'} = \frac{n_i - N_{oi}}{N_i - N_{oi}}$$

N_{oi} – Fatigue damage accumulation does not occur after a certain number of cycles. $\rho(\sigma_i)$ – is a degree indicator and takes into account the property of the material.

By the Karten-Dolan method, the change of damage accumulation in the form of an upper function during repeated repetition of two amplitude voltages was suggested (Figure 1). At this

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time, according to the accumulation of damage at different amplitudes ρ_1 and ρ_2 defined by the upper curves. Damages accepted by the authors reduce the reliability of this met hod [7].

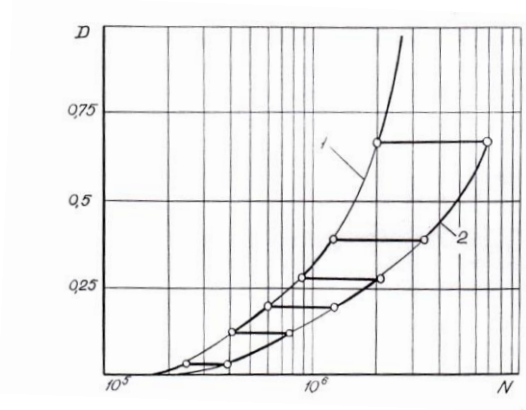

Figure 1: With a change in two voltage levels gradational dependence between damage accumulation

Nishikhara [14] recognizes that the number of cycles required for breakdown increases as the amplitude voltage decreases to the tolerance limit. Damage accumulation is nonlinearly dependent on the number of cycles, and its rate decreases with increasing number of cycles. According to Nishikhara, damage accumulation varies as follows:

$$\frac{dD}{dn} = \frac{1}{N} \cdot e^{-m\sigma(n-1)} \tag{6}$$

where $e^{-m\sigma(n-1)}-$ is a monotonically decreasing function, which indicates that a reduction effect occurs in the accumulation of damage in the endurance limit zone; $m-$ is constant for the material.

V.V.Bolotin [15] proposed two functions for accumulation of damage: the first function expresses the function of accumulation of damage until the formation of cracks and is expressed as follows:

$$D = \frac{n}{N_0}; \qquad n \le N_0 \tag{7}$$

The second function shows the accumulation of damage in the process of crack development and is expressed as follows:

$$D = 0; \qquad n \le N_0 \tag{8}$$

$$D = \frac{n - N_0}{N - N_0}; \qquad n \ge N_0 \tag{9}$$

where N_0- is the number of cycles corresponding to the establishment point of the fatigue curve.

A number of authors (Blazervik, Kawamoto, Miller, Kobugi and others) act from the point of view of cyclic-plastic deformations. They argue that collapse occurs when plasticity disappears and that damage is directly proportional to plastic deformations. The disadvantage of this method is that the rate is assumed to be constant throughout the dissolution process. In addition, the effect of crack development at small stresses is not taken into account.

However, in a number of articles [3,5,7,16] it is noted that the hypothesis of linear summation of damages was not confirmed in the experiments. In particular, it is suggested that this happens when load blocks are repeated many times, that is, during the time when part of the voltage spectrum is located below the tolerance limit.

In a number of works, the evaluation of fatigue damage is performed on the idea of change of endurance limit [21]. In these works, the lowering of the endurance limit is indicated by expressions taken from experience.

V.V.Serensen developed a method of calculating machine parts taking into account the change of the tolerance limit. The drop in the tolerance limit in single-step loadings is expressed as follows:

$$\Delta\sigma_{-1} = \sigma_{-1} \cdot S_n \cdot K\left(\frac{\sigma_n}{\sigma_{-1}} - 1\right) \cdot \frac{1}{\frac{\sigma_n}{\sigma_{-1}} - S_n^2}, \tag{10}$$

where $\Delta\sigma_{-1}$ – decrease in tolerance; $S_n = \frac{n_n}{N_n} - \sigma_n$ degree of overload damage; K – is a factor that takes into account the material and stress concentration.

In multi-stage loadings, the expression (10) is taken as follows:

$$\Delta\sigma_{-1} = \sigma_{-1} \cdot S_n \cdot K \cdot \sum\sigma_i\left(\frac{\sigma_n}{\sigma_{-1}} - 1\right) \cdot \frac{1}{\frac{\sigma_n}{\sigma_{-1}} - S_n^2}, \tag{11}$$

It is claimed by Henry [19] that all the ordinates of the second fatigue curve in one-step loadings are lower than the final curve (Figure 2). A decrease in tolerance is expressed as:

$$\sigma_{-1} - \sigma'_{-1} = \sigma_{-1} \cdot \frac{n_1}{N_1}\left(\frac{\sigma_1}{\sigma_{-1}} - 1\right)\frac{1}{\frac{\sigma_1}{\sigma_{-1}} - \frac{n_1}{N_1}}, \tag{12}$$

where σ'_{-1} – is the tolerance limit of the damaged material.

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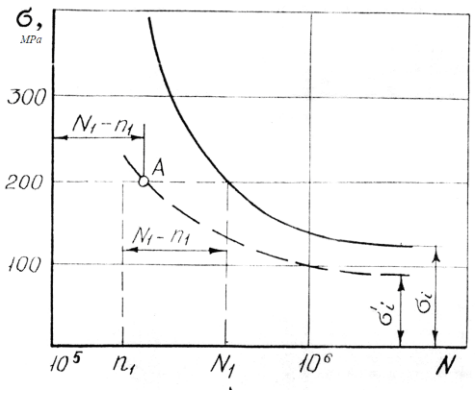

Figure 2: Formation of the second fatigue curve

As a result of experiments conducted by S.V.Serensen and V.P.Kogayev, a corrected hypothesis of fatigue damage was put forward [5]:

$$\alpha_p = \frac{\frac{\sigma_{max}}{\sigma_{-1}}\xi - R}{\frac{\sigma_{max}}{\sigma_{-1}} - R} = \frac{\sum \sigma_i t_i - R \cdot \sigma_{-1}}{\sigma_{max} - R \cdot \sigma_{-1}} \quad (13)$$

where

$$\zeta = \frac{1}{\sigma_{max}} \sum_{i=1}^{r} \sigma_i \cdot t_i \; ; \quad (14)$$

R – constant number defining the low level of damaging voltage; σ_{max} – maximum amplitude of spert; t_i – the relative number of cycles of the σ_i amplitude effect in the program block; r – level number of amplitudes in the block.

The value of the low level of the damaging voltage was taken as 0.6 and 0.5, respectively, in the articles [16,20].

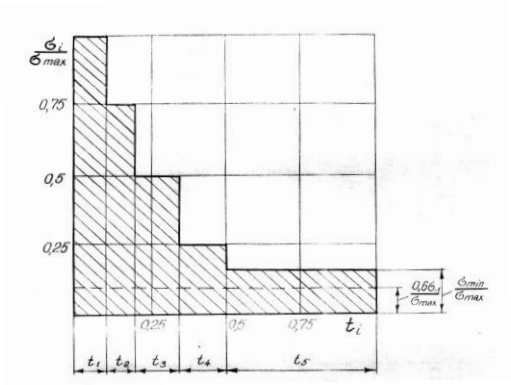

Figure 3: Spectrum voltages in the program block in relative size

Figure 3 shows the voltage spectra in the program block in relative dimensions. According to the authors [20], with the increase of hatched areas, the total of relative longevity decreases. Reduction of hatched areas $\frac{\sigma_{min}}{\sigma_{max}}$ depends on the ratio and the relative duration of the amplitude of the voltages.

In recent years, a number of new damage accumulation hypotheses have been put forward. According to Professor Gnilke [21], the longevity of machine parts is based on the theory of general decay. In this case, a non-linear dependence between damage and stress amplitude was assumed as the mechanical modulus of damage:

$$D = \frac{1-\left(\frac{\sigma_D}{\sigma_{-1}}\right)^{\gamma}}{\left(\frac{1}{S_b}\right)^{\gamma}} \qquad (14)$$

where S_b – the strength reserve factor,

$$S_b = \frac{\sigma_b}{\sigma_{max}} = \frac{\sigma_{-1}}{\sigma_{DB}}$$

σ_{DB} – is a stress level below which damage accumulation does not occur; σ_D – is the true tolerance limit; is the damage rate coefficient.

Figure 4 shows the various curves constructed by expression (14). From here it can be concluded that the damage rate coefficient (γ) is a freely selectable parameter.

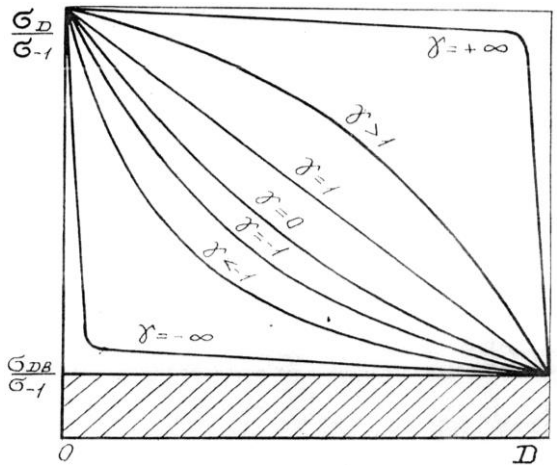

Figure 4: Options for functional solution of damage collection

$\gamma = \infty$ if the expression (14) indicates the Mayner hypothesis, $\gamma = 0, \sigma_{DB} = 0$ and if the damage accumulation linear hypothesis.

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It should be noted that through experiments it was determined that the results of the calculation methodology for the longevity of machine parts developed by professors Gnilke and Serensen-Kogayev are close to each other. Considering that the Serensen-Kogayev hypothesis is deep and widespread, then the correctness of the hypothesis put forward by Professor Gnilke and its use in reporting the longevity of machine parts subjected to loading is of great scientific importance.

Conclusıon:

1. The collection of possible methods for non-stationary regimes is not considered valid and has not been fully justified from a physical point of view. From a physical point of view, the direction of the processes occurring is determined by the Kertan-Dolan method. However, this method itself requires further development and accuracy. Linear summation by the Dahlgren-Meiner method is generally incorrect, and its verification is already considered in this aspect.
2. In the selection of materials working to fatigue in non-stationary regimes, along with other characteristics, it is necessary to take into account the criterion of sensitivity to loads.
3. Longevity reporting in non-stationary regimes should refer to changes in material properties and generalized fatigue diagram.

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YÜKQALDIRICI KRAN HİSSƏLƏRİNDƏ ZƏDƏLƏNMƏLƏRİN CƏMLƏNMƏSİNİN TƏDQİQİ

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XÜLASƏ

Yükqaldıran kranın hissələri qeyri-sabit və dəyişkən yüklərin təsiri şəraitində işləyir. Qeyri-stasionar tsiklik sınaqlarda yorğunluqdan yaranan zədələr xətti cəmlənməsi fərziyyəsi təsdiqlənmir. Dəyişən gərginliklərin təsiri altında zədələrin tədricən yığılması prosesi baş verir ki, bu da tədricən artan və makroskopik zədərlər yaradan müxtəlif təbiətdəki çatların meydana gəlməsinə səbəb olur.
Təqdim olunan məqalə yükqaldırıcı kran hissələrinin zədələnməsinə səbəb olan gərginlik konsentrasiyasının öyrənilməsinə həsr edilmişdir. Tədqiqatın nəticələri müəyyən etdi ki, qeyri-stasionar rejimlər üçün mpvcud metodlar toplusu etibarlı hesab edilmir və fiziki baxımdan tam əsaslandırılmamışdır.
Qeyri-stasionar rejimlərdə yorğunluq rejimində işləyən materialları seçərkən, digər xüsusiyyətlərlə yanaşı, yüklərə həssaslıq meyarı da nəzərə alınmalıdır.
Açar sözlər: pilləli yükləmə, zədələnmə, hipotez, təcrübə, ikinci yorğunluq əyriləri.

ИССЛЕДОВАНИЯ КОНЦЕНТРАЦИИ ПОВРЕЖДЕНИЯ ДЕТАЛЕЙ ПОДЬЕМЫХ КРАНОВ

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РЕЗЮМЕ

Детали кранов работают с нестационарными переменными нагрузками. Гипотеза о линейном суммировании усталостных повреждений при нестационарных циклических испытаниях не подтверждается. Под действием переменных напряжений происходит процесс постепенного накопления повреждений, что приводит к образованию трещин различного характера, которые постепенно увеличиваются, образуя макроскопические значения.

Работа посвящена исследованию концентрации напряжения, приводящие к повреждения деталей подъемных кранов. Результатами исследований было установлено что, набор возможных методов для нестационарных режимов не считается действительным и не был полностью оправдан с физической точки зрения. С физической точки зрения направление происходящих процессов определяется методом опускания занавеса. Однако сам этот метод требует дальнейшего развития и точности. Применение метода Дальгрена-Манера, неточно описывает процесс и его применения некорректен. При выборе материалов, работающих на усталость в нестационарных режимах, наряду с другими характеристиками, необходимо учитывать критерий чувствительности к нагрузкам.

Ключевые слова: ступенчатые нагружение, гипотез, повреждение, вторенные кривые усталости, эксперимент.

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MATHEMATICAL EQUATIONS FOR TEMPERATURE CONTROL IN THE CONTACT SURFACES OF DRILLING AND MAINTENANCE EQUIPMENT

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ABSTRACT

The maintenance of equipment and tools used in the workover of oil and gas wells depends on keeping them in working condition, reliability, strength and temperature endurance of the tool.
In order to restore wells in case of an accident and bring them back into operation, it is necessary to speed up the drilling and repair work by choosing the right repair equipment and following the existing rules and regulatory documents.
The cutting elements of the tools working under high pressure and loads are deformed, a tense situation is created in the cutting – destruction zone, high temperatures (1000^0 - 1200^0) occur as a result of corrosion in the triboknots.
The stress-deformation state in the cutting-destruction zone causes the formation of microcracks in the working area of the tool. Microcracks grow after a certain period of time. Cutting elements are quickly worn, in some cases broken and fail quickly. Such cases affect the structural composition of the cutting elements, the temperatures increase, as a result, riveting occurs.
In order to keep the equipment and tools used in the repair in normal working condition, adjusting the mode parameters is one of the important requirements, in addition to taking special care of them. The high results obtained in repair and restoration works depend on the efficiency of the cutting-destructive tool, longevity, material selection, construction manufacturing technologies, tool that meet modern requirements, dimensions, weight and internal condition of the well being restored.
It is necessary to keep the heat generated in the moving parts of the tool at the required level for the safe performance of restoration works.
The thermal regime of cutting and rock-destroying tools depends on the physical-mechanical properties of the objects subjected to destruction and the effect of thermomechanical stresses generated on the contact surfaces of the tool and the amount of heat released from the working surface.
Studying the problems related to heat issues will allow to ensure the temperature tolerance of not only the repair equipment, but also the equipment and tools used in other areas of the oil-field industry.
Keywords: temperature, cutting and destructive tool, metal, rock.

Introduction:

In the well workover, during the technological operation inside the well and during the destruction of rocks, the temperatures separated from the surface during heat conduction and convective heat exchange on the touching surfaces of cutting elements in the reinforced area and the deformation-stress state on the touching surfaces lead to an increase in stresses.
The study of the regularities of heat transfer processes will serve to reduce thermal stresses on the contact surfaces of metals and other alloy compounds where the cutting part of the tool is reinforced. Studying the regularities of heat conduction is one of the important issues in solving problems related to temperatures.

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In the analytical solution of problems related to heat transfer, objects are considered as a whole medium. Taking into account heat transfer coefficients, heat transfer is aimed at reducing temperatures on the touching surfaces of the tool, reducing temperature stresses in the working areas of the tool [1,2].

Task setting: Determination of differential equation writing, taking into account boundary conditions, which ensure reduction of temperatures generated in tribonodes and contact areas of equipment and tools used in repair and restoration works.

Task solution: In order to achieve the solution of the task, the effect of the temperatures generated on the surface of roller bit of milling type is considered.

The temperatures generated on the supports and touching surfaces of the tool depend on the mode parameters, the physical and mechanical properties of the objects exposed to the cutting, and the dimensions of the structure [3,4].

In real conditions, since the surface of a tool with a cone is cylindrical, its rotation radius is taken as the equivalent radius and the mass of the cone is determined as follows.

$$m = \frac{4}{3}\pi\rho(R^3 - r_0^3) \tag{1}$$

m_c is the mass of the cone; ρ is the density of the material of the cone; R is the outer radius of the cone; r_0 is the inner radius of the cone.

The heat equation for cylindrical bodies is expressed as follows:

$$\frac{\partial \Delta T}{\partial t} = \alpha\left[\frac{2}{r}\frac{\partial \Delta T}{\partial r} + \frac{\partial^2 \Delta T}{\partial r^2}\right] \tag{2}$$

$$\Delta T = T_{(r,t)} - T_0 \tag{3}$$

T_0 – are the starting temperatures, when $T_0 \to t$, $T_0 \to t = 0$. For this reason $t = 0 \Rightarrow \Delta T_{(r,0)} = 0$.

Since the initial condition T_0 is constant for the given conditions, if to consider expression (3) and (2), then:

$$\frac{\partial T_{(r,t)}}{\partial t} = \alpha\left[\frac{2}{r}\cdot\frac{\partial T_{(r,t)}}{\partial r} + \frac{\partial^2 T_{(r,t)}}{\partial r^2}\right] \tag{4}$$

α is the heat transfer coefficient.

$$\alpha = \frac{\lambda}{\rho c} \tag{5}$$

λ –the heat conducting coefficient; ρ – the density of the material; c – the specific heat capacity.

In order to simplify the expression (4), it is necessary to choose such function "U" that has the form $U=r\cdot T(r,t)$.

If to consider the function U in expression (4), then[5]:

$$T_{(r,t)} = \frac{U}{r}; \tag{6}$$

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$$\frac{\partial}{\partial t}\left(\frac{U}{r}\right) = \alpha\left[\frac{2}{r}\frac{\partial}{\partial r}\left(\frac{U}{r}\right) + \frac{\partial^2}{\partial r^3}\left(\frac{U}{r}\right)\right];$$

From (4):

$$\frac{1}{r}\frac{\partial U}{\partial t} = \alpha\left(\frac{2}{r}\left(\frac{1}{r}\frac{\partial U}{\partial r} - \frac{U}{r^2}\right) + \frac{1}{r}\frac{\partial^2 U}{\partial r^2} - \frac{2}{r^2}\frac{\partial U}{\partial r} + \frac{2U}{r^3}\right) \quad (7)$$

If to simplify the expressions in brackets, then we get:

$$\frac{1}{r}\cdot\frac{\partial U}{\partial t} = \alpha\frac{1}{r}\frac{\partial^2 U}{\partial r^2} \quad (8)$$

From here:

$$\frac{\partial U}{\partial t} = \alpha\frac{\partial^2 U}{\partial r^2} \quad (9)$$

The expression $U = r\,T_{(r,t)}$ varies within the limits ($0 \le r \le R$):

1. $r = 0 \quad \rightarrow \quad U = 0$
2. $t = R \quad \rightarrow \quad U = R\,T_{(R,t)}$
3. $t = 0 \quad \rightarrow \quad U = f_{(r)}$

Under conditions 1 and 2 in the expression $U=r\,T_{(r,t)}$, when $t=0$, then $T_{(r,t)}=T_{(r,0)}$ and $U=r\,T_{(r,0)}$.

That is, the function U becomes a function that depends only on r. This function is also called f_v function.

According to the 1st condition we accept U as $U = A_n \sin\frac{n\pi r}{2R}$, then since r=0:

$$U = A_n \sin 0° = 0 \quad (10)$$

In the general case, one can choose such function that satisfies the 2nd and 3rd conditions. For this, it must be taken into account that U depends on both r and f.

If to summarize the obtained results, then it's possible to obtain the following equation:

$$U = g_{(t)}A_n \sin\frac{n\pi r}{2R} \quad (11)$$

$g_{(t)}$ is a function that depends on t, when $t = 0$ according to the 3rd condition, $g_{(0)}=1$.

The explanation of A_n and n will be given with the Fourier series.

Based on equation (11), we can write the following special derivatives:

$$\frac{\partial U}{\partial t} = A_n \sin\frac{n\pi r}{2R}\frac{\partial g_{(t)}}{\partial t} \quad (12)$$

and

$$\frac{\partial^2 U}{\partial r^2} = -\frac{A_n n^2\pi^2 g_{(t)}}{4R^2}\sin\frac{n\pi r}{2R} \quad (13)$$

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If to write expressions (12) and (13) instead of (11), then we obtain:
Note: since the $g_{(t)}$ is a function that depends only on *t*, we can obtain its special differential with relation to *t* as an ordinary differential, i.e.:
If to write $\frac{\partial g_{(t)}}{\partial t}$ as $\frac{d g_{(t)}}{dt}$ the following is obtained[6]:

$$\frac{\partial U}{\partial t} = \alpha \frac{\partial^2 U}{\partial r^2} \tag{14}$$

$$A_n \sin\frac{n\pi r}{2R} \frac{dg_{(t)}}{dt} = -\alpha \frac{A_n n^2 \pi^2 g_{(t)}}{4R^2} \sin\frac{n\pi r}{2R} \tag{15}$$

If to divide $A_n \sin\frac{n\pi r}{2R}$ in (15) on each side, then:

$$\frac{dg_{(t)}}{dt} = -\frac{\alpha n^2 \pi^2}{4R^2} g_{(t)} \tag{16}$$

$$\frac{dg_{(t)}}{dt} = -\frac{\alpha n^2 \pi^2}{4R^2} dt \tag{17}$$

If to integrate both sides of (17), then the following is obtained:

$$\ln\left(g_{(t)}\right) = -\frac{\alpha n^2 \pi^2 t}{4R^2} + c \ (\text{c}-) \tag{18}$$

$$g_{(t)} = e^{c - \frac{2n^2\pi^2 t}{4R^2}} = e^c \, e^{-\frac{\alpha n^2 \pi^2 t}{4R^2}} \tag{19}$$

Since the expression e^c is constant $(e^c + 0)$, then it's possible to substitute this expression to c.
If to write e^c as c in (15),then:

$$g_{(t)} = c \, e^{-\frac{\alpha n^2 \pi^2 t}{4R^2}} \tag{20}$$

If to consider expression (20) in (11), then:

$$U = c \, A_n e^{-\frac{\alpha n^2 \pi^2 t}{4R^2}} \sin\frac{n\pi r}{2R} \tag{21}$$

The expression $A_n \sin\frac{n\pi r}{2R}$ corresponds to the n_{th} element of the Fourier series. The variable *n* is an expression, which varies from 1 to + ∞, indicating the order of the elements in the sequence.
If we generalize the Fourier series, then the expression (21) is written as follows[7,8]:

$$U = \sum_{n=1}^{\infty} a_n e^{-\frac{\alpha n^2 \pi^2 t}{4R^2}} \sin\frac{n\pi r}{2R} \tag{22}$$

If to take b as $b = \frac{\alpha \pi^2}{4R^2}$, then:

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$$U = \sum_{n=1}^{\infty} a_n e^{-n^2 bt} \sin\frac{n\pi r}{2R} \tag{23}$$

Note: 1. The reason that *n* starts from 1 is that $\sin 0° = 0$. For n = 0. Therefore, the value of "n" is taken from 1 to +∞.

2. The main reason why the constant *c* in the expression (21) is in (23) is that the expression a_n in the series also includes the constant c. For this reason, there is no need to use the constant c.

Then the expression (23) is examined according to the boundary and initial conditions:

1. $r = 0$;

If to replace the condition r = 0 in the expression (23), then since $\sin 0° = 0$, U=0, which satisfies the condition is obtained.

2. $r = R$;

If to consider the condition $r = R$ by a similar rule in (23), then:

$$U = \sum_{n=1}^{\infty} a_n e^{-n^2 bt} \sin\frac{n\pi r}{2R} \quad here \left(b = \frac{\alpha\pi^2}{4R^2}\right) \tag{24}$$

As it can be seen from (24), expression (23) depends only on *t* due to the condition *r*=*R*.

3. $t = 0$;

If to consider the condition $t = 0$ in (23), then the function "*U*" is written as follows:

$$U = \sum_{n=1}^{\infty} a_n \sin\frac{n\pi r}{2R} \quad (e^0 = 0) \tag{25}$$

Thus, expression (23) satisfies to all 3 conditions.

Since $U=r\,T_{(r,t)}$, then:

$$T_{(r,t)} = \sum_{n=1}^{\infty} a_n e^{-n^2 bt} \sin\frac{n\pi r}{2R} \tag{26}$$

Note: Since 1/0 is undefined, the variable *r* is taken within the interval $0 < r \leq R$.

In expression (3), T_0 is the initial temperature, according to condition (3): $t = 0;\ T_{(r,t)} \Rightarrow T_{(r,0)} = T_0$ then:

$$T_0 = \frac{1}{r}\sum_{n=1}^{\infty} a_n \sin\frac{n\pi r}{2R} \Rightarrow r\,T_0 = \sum_{n=1}^{\infty} a_n \sin\frac{n\pi r}{2R} \tag{27}$$

To determine a_n from (27), each side of the equation is multiplied to the expression $\sin\frac{k\pi r}{2R}$:

$$rT_0 \sin\frac{k\pi r}{2R} = \frac{1}{r}\sum_{n=1}^{\infty} a_n \sin\frac{n\pi r}{2R} \sin\frac{k\pi r}{2R} \tag{28}$$

If to take *x* as $x = \frac{\pi r}{2R}$, then:

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$$\frac{2RT_0 x}{\pi}\sin(kx) = \sum_{n=1}^{\infty} a_n \sin(kx)\sin(nx) \tag{29}$$

If to integrate both sides of (29) from negative (-π) to positive (π), then the following is obtained:

$$\frac{2RT_0}{\pi}\int_{-\pi}^{\pi} x\sin(kx)\,dx = \sum_{n=1}^{\infty}\int_{-\pi}^{\pi} a_n \sin(kx)\sin(nx)\,dx \tag{30}$$

Let's consider both sides of (30) separately.

First, let's solve the integral on the right side of the equation:

Since a_n is a constant, it will appear in front of the integral.

Then it is sufficient to solve the following integral:

$$\int_{-\pi}^{\pi}\sin(kx)\sin(nx)\cdot dx = \frac{1}{2}\int_{-\pi}^{\pi}(\cos(k-n)x - \cos(k+n)x)\,dx \tag{31}$$

The number n can take any value from *1* to ∞.

Due to the fact that $n = k$ at a certain stage, according to the states of n and k, two cases are possible at this time:

1. When $k = n$: $k - n = 0 \Rightarrow \cos(k-n)x = 1$ then:

$$\frac{1}{2}\int_{-\pi}^{\pi}(1-\cos(2nx))dx = \frac{1}{4}\left(2x - \frac{1}{n}\sin(2nx)\right)\Big|_{-\pi}^{\pi} = \pi \tag{32}$$

So, the right side of expression (32) will be $a_n\,\pi$.

2. If $k \neq n$:

$$\frac{1}{2}\int_{-\pi}^{\pi}[\cos(k-n)x - \cos(k+n)x]\,dx =$$
$$= \frac{1}{2}\left[\frac{\sin(k-n)x}{k-n} - \frac{\sin(k+n)x}{k+n}\right]_{-\pi}^{\pi} = 0 \tag{33}$$

So for the right side n has to be equal to *k*. Only in this case the integral on the right-hand side takes a non-zero value.

Let's consider the integral on the left side of E_q:

Since $\frac{2}{\pi}$, R, T_0 are constants, we exclude them from the integral. Then it'll be possible to solve the following integral.

$$\int_{-\pi}^{\pi} x\sin(kx)dx \tag{34}$$

When calculating the integral on the right-hand side, the integral can only be solved when $k = n$. Therefore, when calculating the integral on the left side, k = n is considered [9,10].

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Thus:

$$\int_{-\pi}^{\pi} x\sin(nx)dx = \frac{1}{n^2}[\sin(nx) - \mathrm{nx}\cdot\cos(nx)]_{-\pi}^{\pi} = -\frac{2\pi}{n}\cos n\pi \quad (35)$$

Then, on the left side:

$$-\frac{4RT_0}{n}\cos n\pi \quad (36)$$

If to replace the found expressions (33) and (36) (the integrals of the right and left sides of the equation) in the expression (30), then we get:

$$-\frac{4RT_0}{n}\cos(n\pi) = \pi a_n \Rightarrow a_n = -\frac{4RT_0}{n\pi}\cos(n\pi) \quad (37)$$

If to consider the expression (37) found for a_n in the expression (23), then the following equation is obtained:

$$T_{(r,t)} = -\frac{4RT_0}{r\pi}\sum_{n=1}^{\infty}\frac{\cos(n\pi)}{n}e^{-n^2bt}\sin\frac{n\pi r}{2R} \quad (38)$$

Since solution of $\cos(n\pi)$ is only within the values -1 and +1:

$$\cos(n\pi) = (-1)^n \quad (39)$$

If to consider (39) in (38), then:

$$T_{(r,t)} = -\frac{4RT_0}{r\pi}\sum_{n=1}^{\infty}\frac{(-1)^n}{n}e^{-n^2bt}\sin\frac{n\pi r}{2R} \quad (40)$$

* If to consider $r = R$ as a special case, then expression (36) becomes a function depending only on t, the following is obtained.

$$\sum_{n=1}^{\infty}\frac{(-1)^n}{n}r^{-n^2bt}\sin\frac{n\pi r}{2R},$$

After performing some mathematical transformations for the expression, the following expression is obtained:

$$T_{(t)} = -\frac{4T_0}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^n}{2n-1}\cdot e^{-(2n-1)^2bt} \quad (41)$$

This case is a special case. The expression (37) is valid only when the boundary condition in the solution of the task is $r = R$. Expression (36) is the final solution of equation (2) that we want to determine with dependence to temperatures.

Thus, the given equation (2) and the initial boundary conditions related to thermal problems for cylindrical bodies satisfied the solution of the equation.

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Equation (36) allows to adjust the temperatures and temperature stresses generated on the contact surfaces of the cutting and rock-destroying tools.

Conclusions

1. Mathematical writing of thermal issues has been determined considering thermal stresses, heat conduction and heat transfer coefficients affecting temperatures in the tribonodes and contact areas of the cutting tools used in the restoration works in wells.
2. The final solution of the differential equation has been obtained, according to the accepted initial and boundary conditions depending on the radius dimensions of the tool in solving the problems related to heat transfer in the contact areas of the cylindrical cutting equipment and tools.

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QAZMA VƏ TƏMİR AVADANLIQLARININ TOXUNMA SAHƏLƏTİNDƏ YARANAN TEMPERATURLARIN TƏNZİMLƏNMƏSİNİ TƏMİN EDƏN TƏNLİKLƏR

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XÜLASƏ

Neft və qaz quyularının əsaslı təmirində istifadə olunan avadanlıq və alətlərin işlək vəziyyətdə qalması, alətin etibarlılığından, möhkəmliyindən və temperaturlara qarşı dözümlülüyündən asılıdır.
Qəzalı vəziyyətdə olan quyuları bərpa edərək yenidən fəaliyyətə qaytarmaqdan ötrü, təmir avadanlıqlarını düzgün seçməklə və onlardan mövcud qaydalara və normativ sənədlərə riayyət etməklə qazmada və təmirdə görüləcək işləri sürətləndirmək olar.
Yüksək təzyiq və yük altında işləyən avadanlıq və alətlərin kəsici - doğrayıcı elementləri deformasiyaya uğrayır, kəsmə - dağıtma zonasında gərginlikli vəziyyət yaranır, tribodüyünlərdə yeyilmələr nəticəsində yüksək temperaturlar (1000^0 - 1200^0) yaranır.
Kəsmə - dağıtma zonasında yaranan gərginlikli - deformasiyalı vəziyyət alətin işlək sahəsində mikroçatların yaranmasına səbəb olur. Mikroçatlar müəyyən müddət keçdikdən sonra böyüyür. Kəsici elementlər sürətlə yeyilir, bəzi hallarda qırılır və tez bir zamanda sıradan çıxır. Bu cür hallar kəsici - doğrayıcı elementlərin struktur tərkibinə təsir edir, metallarda struktur qəfəs dağılır, temperaturlar artır, nəticədə pərçimlənmələr baş verir.
Təmirdə istifadə olunan avadanlıq və alətləri işlək vəziyyətdə saxlamaqdan ötrü onlara xüsusi qulluq etməklə yanaşı, həmdə rejm parametrlərini tənzimləmək vacib şərtlərdən biridir. Təmir - bərpa işlərində əldə olunan yüksək nəticələr kəsici - dağıdıcı alətin səmərəliliyindən, uzunömürlülüyündən, material seçimindən, müasir tələblərə cavab verən konstruksiyanın hazırlanma texnologiyalarından, qabarit ölçülərindən, çəkisindən və təmir işləri aparılan quyunun daxili şəraitindən asılıdır.
Təmir - bərpa işlərinin təhlükəsiz yerinə yetirilməsindən ötrü alətin hərəkətli hissələrində yaranan istilik - fiziki rejmləri tələb olunan səviyyədə saxlamaq tələb olunur.
Kəsici - doğrayıcı və süxurdağıdıcı alətlərin istilik rejmi dağılmaya məruz qalan obyektlərin fiziki - mexaniki xüsusiyyətlərindən və alətin toxunma səthlərindəyaranan termomexaniki gərginliklərin təsirindən və işçi səthdən ayrılan istilik miqdarından asılıdır.
İstilik məsələləri ilə bağlı problemlərin öyrənilməsi yalnız təmir acadanlıqlarının deyil, ümumiyyətlə neft - mədən sənayesinin digər sahələrində istifadə olunan avadanlıq və alətlərin temperaturlara qarşı dözümlülüyünü təmin etməyə imkan verəcək.
Açar sözləri: temperatur, kəsici - doğrayıcı və dağıdıcı alət, metal, süxur.

МАТЕМАТИЧЕСКИЕ ВЫРАЖЕНИЯ РЕГУЛИРОВАНИЯ ТЕМПЕРАТУРЫ В КОНТАКТНЫХ ПОВЕРХНОСТЯХ БУРЯЩЕГО И РЕМОНТНОГО ОБОРУДОВАНИЯ

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РЕЗЮМЕ

Содержание оборудования и инструмента, используемых при ремонте нефтяных и газовых скважин, зависит от поддержания их в рабочем состоянии, надежности, прочности и температурной выносливости инструмента.

Для восстановления скважин в случае аварии и ввода их в эксплуатацию необходимо ускорить выполнение буровых и ремонтных работ за счет правильного выбора ремонтного оборудования и соблюдения действующих правил и нормативных документов.

Режущие элементы инструментов, работающих под высоким давлением и нагрузками, деформируются, в зоне резания-разрушения создается напряженная ситуация, в результате коррозии в трибоузлах возникают высокие температуры (1000^0 - 1200^0).

Напряженно-деформационное состояние в зоне резания-разрушения вызывает образование микротрещин в рабочей зоне инструмента. Микротрещины растут через определенный промежуток времени. Режущие элементы быстро изнашиваются, в ряде случаев ломаются и быстро выходят из строя. Такие случаи влияют на конструктивный состав режущих элементов, повышается температура, в результате чего происходит клепка.

Для поддержания оборудования и инструмента, используемых в ремонте, в нормальном рабочем состоянии, регулирование параметров режима является одним из важных требований, помимо особого ухода за ними. Высокие результаты, получаемые при ремонтно-восстановительных работах, зависят от эффективности режуще-разрушающего инструмента, долговечности, выбора материала, технологии изготовления конструкции, инструмента, отвечающего современным требованиям, габаритам, массе и внутреннему состоянию восстанавливаемой скважины.

Необходимо поддерживать тепло, выделяющееся в подвижных частях инструмента, на необходимом уровне для безопасного выполнения восстановительных работ.

Тепловой режим режущих и породоразрушающих инструментов зависит от физико-механических свойств объектов, подвергаемых разрушению, действия термомеханических напряжений, возникающих на контактных поверхностях инструмента, и количества тепла, выделяющегося с рабочей поверхности.

Изучение проблем, связанных с тепловым режимом, позволит обеспечить температуроустойчивость не только ремонтного оборудования, но и оборудования и инструмента, применяемых в других областях нефтепромысловой отрасли.

Ключевые слова: температура, режущий и разрушающий инструмент, металл, горная порода.

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METHODS OF FIGHTING WITH MILITARY EMERGENCIES

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ABSTRACT

The article provides a new classification of emergency situations of a military nature. Quantıtatıve and qualıtatıve indicators of military emergencies were studied. Safety criteria in dealing with emergency situations have been defined. Information has been provided on emergency rescue and other urgent tasks during the prevention and elimination of the consequences of emergency situations of a military nature. During the fight against emergency situations of a military nature, a single system was studied, and the main goals and tasks for emergency rescue operations were determined. The importance of the classification of emergency situations according to the incident during the accident-rescue and search-rescue works was studied and the directions of action were determined. The significance of emergency planning and the classification of cases during the use of modern means of destruction, i.e., weapons of mass destruction and conventional means of destruction, in the case of military emergency events and other urgent work arrangements in peacetime have been studied. The necessity of developing a preventive policy for combating emergency situations of a military nature was determined, the issues of developing universal principles of conducting operations against emergency situations of a military nature, and systematizing the procedure of coverage of war-related situations in the mass media were considered. In real conditions, the importance of differentiating emergency-rescue work from other urgent work has been determined.
Keywords: emergencies, military, rescue, security, character.

Introduction

Despite the achievements of scientific and technical progress, the danger of disaster for society continues to increase. The number of victims of natural and man-made events increases by about 6% every year. According to the Epidemiological Disaster Science Center (Brussels), 3.6 million people died as a result of natural disasters in 1965-1992, more than 3 billion people were injured, and the total economic damage was more than 340 billion dollars. The data submitted by various countries to the World Conference on Natural Disasters (Yokohama, 1994) show that between 1962 and 1992, the country suffered serious economic losses (up to 1% of the annual gross domestic product and more), the number of natural disasters was 4 ,1 times, and the number of victims increased by 2.1 times.

However, the number of wars, acts of terrorism and various armed conflicts in the world is constantly increasing. Consequences of conflict emergencies also cause very serious economic and human losses [2].

Purpose of work

Floods, droughts and earthquakes are natural disasters that cause the greatest economic losses. These constitute 32, 22 and 10 percent of all emergency incidents, respectively. According to the impact on people, the number of victims during the most dangerous disasters is drought (30%),

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floods (26%), epidemics (17%) and earthquakes (13%). The analysis of statistical data on emergency events that have occurred on Earth in the last 30 years proves that the number of emergency situations of a military nature, terrorist acts and conflicts is constantly increasing. Therefore, increasing the operational capabilities of emergency response units should be considered as the main goal.

A new classification of emergency situations of a military nature was considered as the main goal. Prevention of emergency situations and elimination of the consequences of emergency situations that have occurred are considered to be one of the main issues. The occurrence of emergency events of a military nature leads to the emergence of other types of emergency events. This, in turn, creates serious problems in the field of eliminating the consequences of emergency events. Accurate classification of emergency situations of a military nature has a positive effect on the efficiency indicators of emergency rescue operations.

Main part

There are more than 15 different dangerous natural phenomena in the territory of Azerbaijan, which is distinguished by different geological climate and relief conditions [3].

The most devastating emergencies include:

1. floods
2. erosion
3. earthquakes
4. landslides
5. snow avalanches
6. hurricanes
7. storms
8. eddies

Some of these events (earthquakes, landslides, avalanches, tornadoes) occur unexpectedly and are short-lived, but result in large material losses and human casualties [3]. As we know, an emergency incident at any facility is small-scale and requires little force and means to eliminate it. Since a local emergency covers a larger area, a regional emergency covers the entire region, and a global emergency covers areas on a global scale, each specific emergency differs in terms of combat methods and involved forces and means.

In the case of a military-type emergencies, this difference will apply to all the cases involved in the classification, and in each specific case, it will require more forces and means [4]. For example, events and issues such as the use of modern-type weapons, i.e. phosphorus rockets, the use and testing of special chemical weapons, and the failure to defuse unexploded ordnance in the frontline area, lead to faster depletion of natural potential or a decrease in their utilization rate. As a result of the explosion, the release of toxic substances, gases and toxins into the air leads to the depletion of the atmosphere, which in turn leads to the depletion of water resources and considerable pollution of groundwater.

Based on the analysis of the causes and consequences of various types of emergency events, the structure of damage to nature and natural resources, ecology, the potential threat of military emergency events to natural resources and national security is considered more dangerous compared to other types of emergency situations. The scale of the difficulties and measures in the elimination and minimization of the damage prove that there are serious problems in this area.

In turn, makes the question of conducting a new classification of emergency situations of a military nature even more urgent.

Classification of military emergencies:

– according to the scale - world, local and regional (depending on the volume of military operations and the composition of the warring states);
– by duration - transient and long-lasting;
– by means of destruction — using nuclear and (or) conventional weapons;
– according to intensity - high, medium and low intensity of military actions;
– according to the number of participating states - coalition and one state against another.

According to the qualitative content of a military emergency, the classification level should be completed with the following features:

– according to the nature of participation in the conflict - direct and indirect;
– according to the quality of opposing troops (forces) - regular, irregular or mixed forces, gangs, anti-state terrorist groups.

According to the quantitative content of emergency situations of a military nature, the classification level can be presented as follows:

– according to the location of the conflict zone - within the state, border, far from the state;
– according to the method of release - sudden attack, increased aggression;
– according to the nature of the theater of operations - continental, oceanic, sea, air, space;
– according to the number of troops (forces) involved - from a limited military contingent to operational-strategic grouping of troops (forces) from both sides;
– according to the forms and methods of military operations - operations, combat operations (classical), guerrilla, non-traditional, incomplete, large-scale, blockade, position, maneuver, operations of special forces, anti-terrorist operations;
– according to the duration of military (battle) actions - transient, long-lasting (here - "war of attrition");
– according to the number of states participating in the war - coalition, coalition against one state, state against state.

Classification of threats occurring during emergencies of a military nature

Classification of hazards

Threat - a potentially possible or real action or event that can cause moral or material damage.

by objects:

 internal
 external

according to the degree of influence:

 significant
 less important

according to probability of occurrence:

 presumed
 unlikely

for reasons:

 naturally occurring
 intentionally committed

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in directions:
 economic
 social
for damages:
 material
 spiritual
according to scale:
 local
 global

Summarizing and studying the experience of local wars and armed conflicts, their classification allows to analyze the cause-and-effect relationships of the conditions for the emergence of crisis situations, the methods and characteristics of wars and armed conflicts in the most fundamental way. war and their development trends. In turn, such a study allows drawing lessons, drawing appropriate conclusions, and developing recommendations aimed at preventing future violence and ensuring national security. Nevertheless, if a conflict occurs, knowing the experience of past wars will help to better prepare for the organization of civil defense [5].

In addition, the classification allows the researcher to more precisely define the boundaries of the work.

The classification, together with the analysis of threats in a certain strategic direction, allows to better predict the possible situation, which is important for planning future activities and organizing the protection of the population and territory.

The unified system of combating emergency situations of a military nature is classified as follows:

The security system is an organized set of special bodies, services, means, methods and activities that ensure the protection of the vital interests of a person, society, and the state from internal and external threats. The prevention of threats in the fight against emergency situations depends on the following measures:

Main objectives.

– Hazard identification
– Prevention of danger
– Threat neutralization
– Warning of danger
– Localization of danger
– Repelling danger
– Destruction of danger

Basic tasks.

1. Development and implementation of plans and other measures to protect the interests of people, society, and the state
2. Formation, provision and development of bodies, forces and means of support
3. Restoration of protected objects damaged as a result of illegal actions

Criteria for ensuring safety.

– preventive security measures
– systematic control of capabilities
– timely identification of real threats

– □ measures to eliminate threats
– □ elimination of the damage

Summarizing all this, it should be noted that special measures and operations should be provided for each of the operations to be carried out during the military emergencies. These should include additional operations and measures, such as the prediction of the change in the military situation, mine and PHS clearance in the debris-piles zone, quick response in case of bomb-rocket strikes, and placement in shelters.

Basic rescue and other emergency work in the zone of armed conflict

One of the main directions of combating emergency incidents is increasing the efficiency of emergency rescue units and improving and developing their methods of operation.

Accident-rescue and other urgent works are carried out in order to provide emergency assistance to the affected population, as well as to limit the scale of emergencies, prevent or eliminate their consequences.

During the accident-rescue work, it is carried out in the shortest possible time, taking into account the possibility of increasing losses and the volume of destruction as a result of the effects of both timely first aid to the victims and the impact of subsequent destructive factors (fires, explosions, earthquakes, etc.) [6].

In real conditions, it is difficult to distinguish emergency rescue work from other urgent work, because it is necessary to differentiate them for important parts of the work. Therefore, in practice, accident-rescue work is expressed by a general term, that is, accident-rescue and other urgent work. Accident-rescue and other urgent work in emergency zones is conventionally divided into 3 stages:

the initial stage - implementation of urgent measures for the protection of the population with local forces, rescuing the victims, as well as preparation for the grouping of forces and means for the elimination of emergency incidents and the execution of works;

first stage - carrying out emergency rescue and other urgent work with groups of forces and vehicles;

the second stage - the completion of emergency rescue and other urgent works, the gradual transfer of management functions to the local administration and the withdrawal of force groups, the implementation of measures related to the life support of the population first.

In each specific case, the volume and type of emergency rescue and other urgent work depends on the nature of the disaster that caused the source of destruction (damage).

Emergency incidents of a military nature occur as a result of the use of modern means of destruction, that is, weapons of mass destruction and conventional means of destruction. Weapons of mass destruction include nuclear, chemical and biological (bacteriological) weapons. Conventional means of destruction include ballistic and cruise missiles, artillery and aviation munitions (shells, bombs), mines, fugas (explosive mines), incendiary means, high-explosive munitions, etc. includes. Actions for the organization of emergency rescue and other emergency work at the damage sites are planned and prepared during peacetime. After the enemy attacks, they are refined and carried out taking into account the situation.

For this reason, the classification of emergency situations of a military nature directly helps to develop a plan of preventive measures against such events.

Basic emergency-rescue works

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– □ search for victims in the area of the source of destruction, in the ruins of collapsed buildings and structures, and in other hard-to-reach places
– □ opening and removing the block of victims from protective structures and basements, under the rubble of collapsed buildings
– □ providing first aid to the wounded
– □ evacuation of people from dangerous places, removal to safe places

Additional rescue operations

– □ stoppage of damaged parts in utility and technological networks and localization of accidents
– □ search, detection and neutralization of unexploded ordnance and other explosive objects
– □ organization of roads in the workplace and on routes for the introduction of forces, cleaning of workplaces, fixing and dismantling of unstable structures
– □ organization of commandant service on the damage cordon and adjacent highways
– □ ensuring the safety of aircraft participating in rescue operations

Other urgent matters

– □ localization and extinguishing of fires
– □ decontamination (disinfection) of roads, the territory of buildings and structures, workplaces.
– □ sanitary (special) maintenance of personnel, population, equipment, property and clothing of units and units
– □ restoration of communication lines, energy and utility networks, roads, buildings for rescue operations
– □ technical and logistical support

In general, the development of a unified security system is considered one of the main directions for organizing the fight against emergency situations of a military nature. The development of a unified security system in order to eliminate the consequences of emergency situations and the determination of the main criteria of security have a positive effect on the successful conduct of emergency rescue operations.

The result

War is a complex, multidimensional phenomenon. In addition to legal issues, a number of other problems - psychological, historical, technological, etc. All this leads to the fact that the world community has not yet been able to develop a generally acceptable definition of war and methods of combating emergency situations of a military nature.

Currently, there are quite a variety of forms of war that are studied by criminologists, sociologists, political scientists, and specialists in other sciences. At the same time, new, more advanced forms of war are emerging due to the development of scientific and technical progress.

A competent preventive policy is needed to deal with military emergencies. The identification, elimination, neutralization, localization and minimization of the factors that cause or support wars should become more urgent.

It would be appropriate to consider the development of universal principles of conducting operations against emergency situations of a military nature, the careful regulation of the procedure for the coverage of war-related situations in the mass media, and the creation of a single data bank on the manifestations of various forms of war.

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During military emergencies, the current tactics of emergency rescue operations and the characteristics of other non-delayed tasks were analyzed, as a result of the comparative analysis of the tactics of various emergency rescue teams, the constant improvement and renewal of emergency rescue tactics was characterized and operative management issues were identified. issues that include the stages of solution have been studied. Quantitative and qualitative indicators of emergency situations of a military nature were studied and the main tasks and tasks for emergency rescue operations were determined.

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HƏRBİ XARAKTERLİ FÖVQƏLADƏ HALLARLA MÜBARİZƏNİN ÜSULLARI

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XÜLASƏ

Məqalədə hərbi xarakterli fövqəladə halların yeni təsnifatı verilmişdir. Hərbi xarakterli fövqəladə halların kəmiyyət və keyfiyyət məzmununa görə göstəriciləri tədqiq edilmişdir. Fövqəladə hallarla mübarizədə təhlükəsizlik meyarları müəyyən edilmişdir. Hərbi xarakterli fövqəladə halların qarşısının alınması və nəticələrinin aradan qaldırılması zamanı qəza-xilasetmə və digər təxirə salınmaz işlər haqqında məlumat verilmişdir. Hərbi xarakterli fövqəladə hallarla mübarizə zamanı vahid sistem tədqiq edilmiş, qəza-xilasetmə əməliyyatlarının aparılması üçün əsas məqsəd və tapşırıqlar müəyyən edilmişdir. Qəza-xilasetmə və axtarış-xilasetmə işlərinin aparılması zamanı fövqəladə halların təsnifatının əvvəlcədən hadisəyə uyğun olaraq aparılmasının vacivliyi tədqiq

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edilmiş və fəaliyyət istiqamətləri müəyyənləşdirilmişdir. Hərbi xarakterli fövqəladə hadisələr müasir qırğın vasitələrinin, yəni kütləvi qırğın silahları və adi qırğın vasitələri tətbiq edilməsi zamanı qəza-xilasetmə və digər təxirəsalınmaz işlərin təşkilinə dair tədbirlərin dinc dövrdə planlaşdırılırması əhəmiyyəti və işlərin təsnifatı tədqiq edilmişdir. Hərbi xarakterli fövqəladə hallarla mübarizə üçün qabaqlayıcı siyasətin işlənməsi zəruriliyi müəyyən edilmiş, hərbi xarakterli fövqəladə hallar əleyhinə əməliyyatların aparılmasının universal prinsiplərinin işlənib hazırlanması, müharibə ilə bağlı vəziyyətlərin kütləvi informasiya vasitələrində işıqlandırılması prosedurunun sistemləşdirilməsi məsələlərinə baxılmışdır. Real şəraitlərdə qəza-xilasetmə işlərini digər təxirəsalınmaz işlərdən fərqləndirilməsinin vacibliyi müəyyən edilmişdir.
Açar sözlər: fövqəladə hallar, hərb, qəza-xilasetmə, təhlükəsizlik, xarakter.

СПОСОБЫ БОРЬБЫ С ЧРЕЗВЫЧАЙНЫМИ СИТУАЦИЯМИ ВОЕННОГО ХАРАКТЕРА

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РЕЗЮМЕ

В статье представлена новая классификация чрезвычайных ситуаций военного характера. Изучены количественные и качественные показатели военных чрезвычайных ситуаций. Определены критерии безопасности при действиях в аварийных ситуациях. Приведена информация по аварийно-спасательным и другим неотложным задачам при предупреждении и ликвидации последствий чрезвычайных ситуаций военного характера. В ходе борьбы с чрезвычайными ситуациями военного характера изучена единая система, определены основные цели и задачи проведения аварийно-спасательных работ. Изучено значение классификации аварийных ситуаций по происшествию при проведении аварийно-спасательных и поисково-спасательных работ и определены направления действий. Изучено значение аварийного планирования и классификации случаев при применении современных средств поражения, т. е. оружия массового поражения и обычных средств поражения, в случае военных чрезвычайных ситуаций и других неотложных работ в мирное время. Определена необходимость разработки превентивной политики борьбы с чрезвычайными ситуациями военного характера, вопросы разработки универсальных принципов ведения операций по ликвидации чрезвычайных ситуаций военного характера, систематизации порядка освещения военных ситуаций в средствах массовой информации. считались. В реальных условиях определена важность разграничения аварийно-спасательных работ от других неотложных работ.
Ключевые слова: чрезвычайные ситуации, война, спасение, безопасность, характер.

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ADVANCED TECHNOLOGIES IN STEEL PRODUCTION

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ABSTRACT

Continuous casting is essentially the youngest and most dynamically developing technology in the steel production and casting system as an industrial method of shaped casting process. At present, continuous casting of steel is adopted in more than 90 countries of the world. About 2,000 continuous casting machines (CCMs) of different purposes and designs are now in good operation, which allow casting about 93% of all steel produced in the world. At this time, steel bars with the following maximum cross-sections are produced in the industry: blue 600×670mm, slab 250×3200mm and circular bars with a diameter of 600mm. In many developed countries of the world, almost 95-100% of steel production is produced by continuous casting. is being for example, in 2018, 1.228 billion tons of steel were produced by continuous casting in the world, which is a record in the history of metal production. as a result of experimental studies, proposals were developed for the application of important technologies in the development of non-furnace processing of liquid metal and continuous casting in the Republic.
Keywords: Steel making, permanent casting devices, construction, vacuuming, liquid metal, intermediate heat, temperature, impact viscosity, electrometallurgy.

Introduction: One of the most important issues in the production of electro steel is the adjustment of the chemical composition of steel, bringing it to the standard. Electrometallurgy of steel is a multi-stage process. One of the most important issues in the production of electro steel is the method of pouring liquid steel. One of the innovative technologies of recent times is the continuous casting process. This process is considered to be the final step in steel production. In this case, the molten steel pellets are released into the continuous casting machine (PFTM). The continuous casting technology is considered the most advanced and effective method for making pies. The essence of the method is that liquid steel is poured into a metal mold cooled by water, the ingot is drawn continuously from the metal mold and then cut into pies of the required size.

Obtained results and their analysis.
Arrangement of improved furnace stirring device, which performs combined pneumatic and electromagnetic mixing of metal in steelmaking complexes of the country. This device organizes the temperature and chemical homogeneity of the liquid metal within the given limits, enabling the refining of a large variety of steels. The use of circulating vacuumators that allow blowing oxygen and abrasive reagents, as well as heating the liquid metal. allows to ensure the high quality of metal products during distribution. Equipping vacuumators of this form with structures for gas-oxygen refining of austenitic stainless steels. Such structures create conditions for the production of steels containing C<0.02%; it allows to increase their resistance to rusting by at

least 50%, technological plasticity by 30%, and at the same time to use ferrochrome with carbon during melting. After silicon-free vacuum-carbon deoxygenation of steel in a furnace, the final processing of the alloy with complex alloys of Ca-Al-Mn-Si type. This measure makes it possible to improve the quality and increase technological plasticity due to the 1.5-2 times reduction of the amount of non-metallic compounds in the responsible deformed steels. The use of abrasive wire during processing in the furnace furnace, intermediate furnace and crystallizer for desulfurization and modification of steel. This situation increases the rate of acceptance of modifier substances, especially oxygen-hungry elements; It opens up new opportunities for saving ferro alloys, stabilizing the chemical form of steel, and improving sanitary and hygienic conditions in steelmaking and rolling shops. mastering the shedding. This leads to 2-3 times increase of service reserves of structural and alloyed steels, as well as a significant decrease in the use of alloyed substances. Development of highly useful infrastructure of partitions of intermediate ladles, equipping ladles with forms that have a wide influence on the alloy and ceramic filter pores. Such a situation reduces the pollution of steel by non-metallic compounds by 2-2.5 times, thereby meeting the modern requirements for the quality of steel and foreign standards. Low-carbon construction micro alloyed with nitrogen and vanadium, whose strength is 30-40% higher than that of steels produced by standard technology. mastering the production and continuous casting of steels. This leads to 2-3 times increase in the service life of structural and alloyed steels, as well as a significant decrease in the serviceability of alloyed substances. mastering mixing technology (fig. 1).

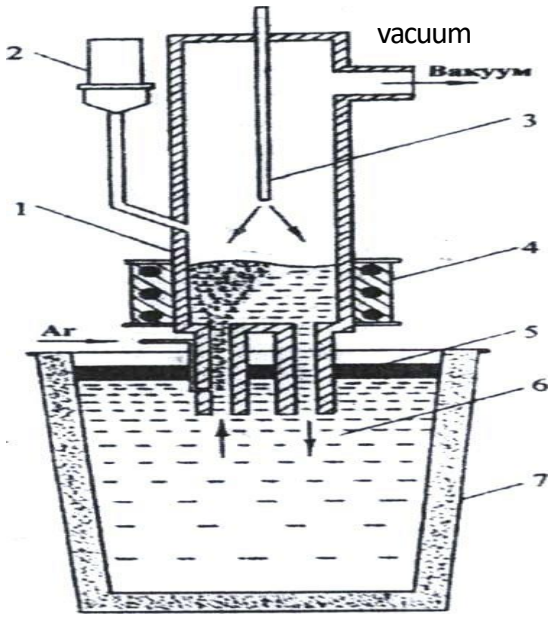

Figure 1: Scheme of the circulating vacuuming device: 1-vacuum chamber; 2-hopper for sprayed reagents; 3-oxygen blowing; 4-inductor; 5-additive; 6-steel; 7-steel pit

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Such a measure leads to a more beneficial purification of non-metallic mixtures (porcelain mixture) than steel and an increase in the structural homogeneity of the pastes, a 10% reduction in the crystallization time of the metal, a reduction in the anisotropy of the mechanical characteristics of the rolling paste, and a 15-25% increase in the impact viscosity at negative temperatures. In machine-building and metallurgical plants organization of new constructions of continuous casting machines with magneto dynamic intermediate furnaces for the production of special steel grades and the technologies of manufacturing them. Organization of a computerized control system for the consumption of metal, the speed of stretching of the continuous pouring paste and the parameters of its second cooling process. The basis of such a form is a complex illuminator and radiolocation, contact and multi-color non-contact continuous control of thermal-physical parameters.

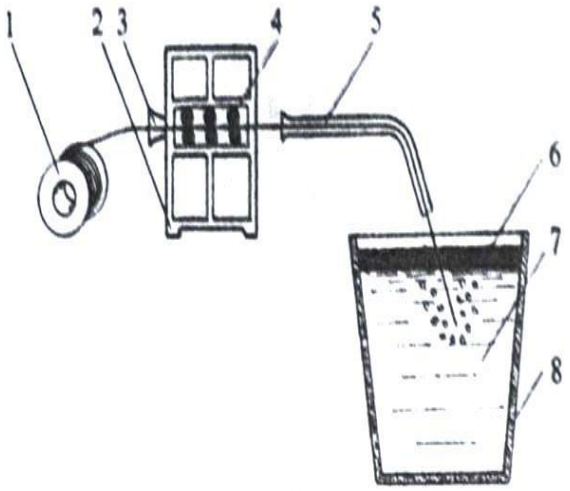

Figure 2: The scheme of feeding the wire in liquid steel: 1- washing the wire;2-trayb-apparatus; 3-receiver bowl; 4-traction rollers; 5-guiding pipe;6-additive; 7-steel; 8- steel pit.

Such inspection allows to control the formation processes of pastas in the crystallizer. At the same time, the temperature of the alloy in the intermediate furnace, the level of the metal in the crystallizer and the thickness of the resin coating, the amount of heat transferred to the crystallizer. All these parameters are precisely controlled. and automatic monitoring allows for the minimum thermal stresses required to obtain a quality rolling paste and to organize the structural homogeneity of the paste, to increase the productivity of the casting process and to prevent the liquid metal from breaking out from under the crystallizer. -used after industrial trials. Among such proposals, it is possible to mention the application of constant current electric arc heaters and plasmators in the furnace. Another proposal is related to the application of a device for desulfurization of steel with magnesium, which is immersed in liquid metal and reduced in the electric arc zone. giving, the proposal to develop a multifunctional magneto dynamic intermediate valve, which provides electromagnetic control of metal consumption without plug and drawer partitions, may also be of interest.

Results and Discussion.

Analysis of the importance of the casting radius in the production of quality steel with a continuous pashto casting machine. As the radius increases, the internal structure of the pashto is more fully formed. Investigation of the selection of cooling zones in the continuous pashto casting machine. Comparison of defects in the structure of steels produced at different radii in a continuous caster that produces 55 tons of liquid metal slag per hour. Calculation of mechanical properties of reinforcing steels produced from slags cast at different radii. Evaluation of the effect on the structure of steel by increasing the casting radius from 4832mm to 10200mm.Examination of the requirements for mechanical and hydraulic equipment, natural gas, oxygen, technical water, and water of the closed circuit used in the four-barrel continuous pashto casting machine. As the radius increases, the variation of the pashtos' geometrical dimensions also increases, it is possible to cast 250*250mm in a radius of 10 m. With the increase of the radius, the length of the liquid metal increases every minute, which means that the productivity also increases. Also, it is possible to have a better quality of the geometric shape and internal structure of the round pashto. Investigation of the requirements for mechanical and hydraulic equipment, natural gas, oxygen, technical water, and water of the closed circuit used in the four-drum continuous pashto casting machine. Analysis of defects in the pashtos cast in the 4-drum continuous Pashto casting machine that produces 125x125x6000 mm.

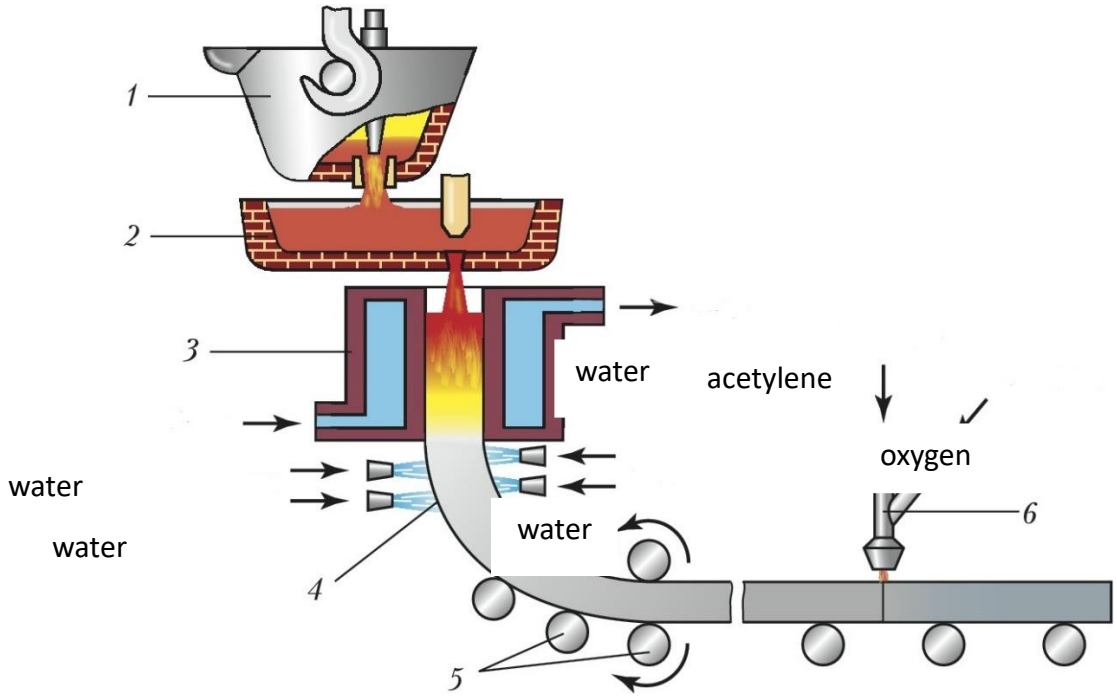

Figure 3: Continuous steel casting:1-Liquid steel coil; 2- Intermediate coil; 3-Crystallizer (crystallizer);4-Second cooling zone and support system of flow rollers; 5-Tensioner-rectifier unit; 6-Cutting hype.

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ПЕРЕДОВЫЕ ТЕХНОЛОГИИ В ПРОИЗВОДСТВЕ СТАЛИ

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РЕЗЮМЕ

Непрерывное литье по существу является самой молодой и наиболее динамично развивающейся технологией в системе производства стали и литья как промышленный способ фасонного литья. В настоящее время непрерывная разливка стали принята более чем в 90 странах мира, в исправном состоянии находится около 2000 машин непрерывного литья заготовок (МНЛЗ) различного назначения и конструкции, которые позволяют разливать около 93% всей производимой в мире стали. В настоящее время в промышленности выпускается стальной прокат следующих максимальных сечений: голубой 600х670мм, горбыль 250х3200мм и круговой прокат диаметром 600мм.Во многих развитых странах мира почти 95-100% производства стали производится методом непрерывной разливки. Например, в 2018 году методом непрерывной разливки в мире было произведено 1,228 млрд тонн стали, что является рекордом в истории производства металла, в результате экспериментальных исследований были разработаны предложения по применению важных технологий при разработке беспечной обработки жидкого металла и непрерывного литья заготовок в республике.
Ключевые слова: Сталеплавильное производство, оборудование непрерывного литья заготовок, строительство, вакуумирование, жидкий металл, промежуточная плавка, температура, ударная вязкость, электрометаллургия.

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POLAD İSTEHSALINDA MÜTƏRƏQQİ TEXNOLOGİYALAR

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XÜLASƏ

Fasiləsiz tökmə pəstahların fasonlu tökmə prosesinin sənaye üsulu kimi mahiyyətcə polad istehsalı və tökülməsi sistemində ən gənc və dinakim inkişaf edən bir texnologiyasıdır. Hazırda poladın fasiləsiz tökülməsi dünyanın 90-dan çox ölkəsində mənimsənilmişdir.Fərqli təyinat və konstruksiyaya malik təxminən 2000 fasiləsiz tökmə maşınları (FTM) indi yaxşı fəaliyyət göstərir, bunlar dünyada istehsal olunan bütün poladın təqribən 93%-ni tökməyə imkan verir. Bu zaman sənaye hüdudunda aşağıdakı maksimal en kəsiklərdə polad pəstahlar istehsal olunur: blyum 600×670mm, slyab 250×3200mm və diametri 600mm olan dairəvi pəstahlar.Dünyanın bir çox inkişaf etmiş ölkələrində polad istehsalının az qala 95–100%-i fasiləsiz tökmə üsulu ilə istehsal olunur.Məsələn, 2018-ci ildə dünyada fasiləsiz tökmə ilə 1,228 mlrd ton pəstah istehsal olunmuşdur və metal istehsalının tarixi ərzində bu rekord göstəricidir.Poladın fasiləsiz tökülməsi prosesi maşınların konstruksiyası və prosesin texnologiyası planı əsasında inkişaf etməkdə davam edir.Tədqiq edilmiş ədəbiyyat və istehsalat icmalı, nəzəri və eksperimental tədqiqatlar nəticəsində Respublikada maye metalın sobadan kənar emalı və fasiləsiz tökmə prosesinin inkişafında vacib texnologiyaların tətbiqinə dair təkliflər işlənmişdir.

Açar sözlər: Poladəritmə, fasiləsiz tökmə qurğuları, konstruksiyası, vakuum-laşdırma, maye metal, aralıq çalov, temperatur, zərbə özlülüyü, pəstahlar.

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INVESTIGATION OF THE MECHANISM OF FABRIC WINDING ON WEAVING MACHINES WITH THE PURPOSE OF INCREASING THEIR PRODUCTIVITY

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ABSTRACT

The state of light industry in the world is still difficult. The downward trend in the production of the most important types of textile products in physical terms continues. An inevitable consequence of the decline in light industry output is a low level of capacity utilization.
The situation in the light industry is further complicated by the fact that most of the existing fixed assets cannot be used in the future without appropriate reconstruction, since the technical and economic parameters of the main part of the equipment do not meet modern requirements and do not ensure the production of competitive products.
The international experience of recent years shows that machine building for the textile and light industries has good prospects for overcoming the crisis and further development. Intensive improvement of technology for these industries is carried out in the following main areas:

- improving equipment performance;
- equipping machines with the most modern microprocessor control and monitoring systems for the technological process;
- robotization of labor-intensive operations for machine maintenance;
- universalization of equipment for various processed raw materials.

Based on the concept of development of textile engineering and the current economic situation in the textile industry, the main areas for improving production are:

- modernization (improvement) of mastered production and mass-produced equipment in the direction of increasing the productivity of machines, increasing the degree of their automation, reliability, ergonomics and workmanship, as well as saving raw materials;
- modernization of equipment operating at textile industry enterprises by replacing individual units, modules, equipping machines and units with automation and instrument control.

To meet the needs of the population for the product of the textile and light industry, it is required to increase the production of fabrics of various assortments. The quality of manufactured fabrics depends on the construction of the mechanisms of looms. One of the mechanisms that affect the quality of the fabric produced on weaving machines is the fabric removal mechanism. This mechanism consists of three devices, a pulling roller (valiance), a commodity regulator and a winding device.
Keywords: Light industry, fabric removal mechanism, winding device, valiance, coefficient of friction.

Introduction. According to the technological scheme of threading looms, the main threads are fed from the warp, bending around the rock, pass through the lamellas of the founder, the heddles

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of the heald frames and reeds approach the edge of the fabric. The warp threads form a shed into which weft threads are inserted and fabric elements are formed. The formed fabric passes through the breast, goes around the felt, the guide film and winds the commodity roller. The fabric removal consists of three mechanisms:
Pulling roller (valance) with a rough surface
Commodity regulator
A winding device
As it is worked out on the loom, the finished fabric is removed from the working area and wound on a commodity roller, forming a roll, and the warp is unwound from the weaving beam, moves in the longitudinal direction and is brought to the working area. Commodity regulators have the following purpose: to take away the finished fabric, winding it on the commodity roller.
Purpose and objectives of research. The purpose of this work is to analyze the kinematic scheme and construction of the goods receiving mechanism in order to automate the technological processes performed by them in weaving machines. The task of the research is:
Analysis of the construction of fabric removal devices;
Analysis of the construction of a winding device.
Analysis of the construction of fabric.
Principal structural diagrams of the device for fabric removal are shown in Fig.1. Based on the analysis of the operation of fabric removal devices, the following basic conditions for fabric removal can be formulated [1].
To ensure that the fabric is not damaged, there must be an appropriate coating on the surface of the valance (felt). Currently, for fabrics made from yarn, rough (in the form of a grater) tin is used. For chemical fibers, the felts are covered with rubber with a protruding relief or a special coating with grooves, a coating of cork, plastics or other friction materials.
The fabric should not slide over the felt in order to maintain the specified weft density. According to the Euler formula, the friction force T should depend only on the friction coefficient f and the wrap angle α :

$$T=S_1- S_2=S_2 (e^{f\alpha} – 1) \quad (1)$$

But this formula is completely valid only for the friction of the fibers. When rubbing the fabric at its full width, the diameter of the roller is also essential. The coefficient of friction depends not only on the material of the roller cover, but also on the type of fiber and the weave of the fabric. Along with the indicated coefficients of friction between the surfaces of the felt and the fabric, the coefficient of friction also depends on the condition of contact of these surfaces, which are determined by the static and dynamic parameters of the felt and the process of surfacing the weft thread to the edge of the fabric with a reed, i.e., on the deformation and frequency of natural vibrations of the felt and the frequency of the weft thread beat to the edge of the fabric [2].
To ensure maintenance and limit time costs, as well as to automate the process of removing forgings, commodity rollers, it must be possible to remove the commodity roller while the machine is working. The fabric should not make a return movement after cutting and removing the finished roller.

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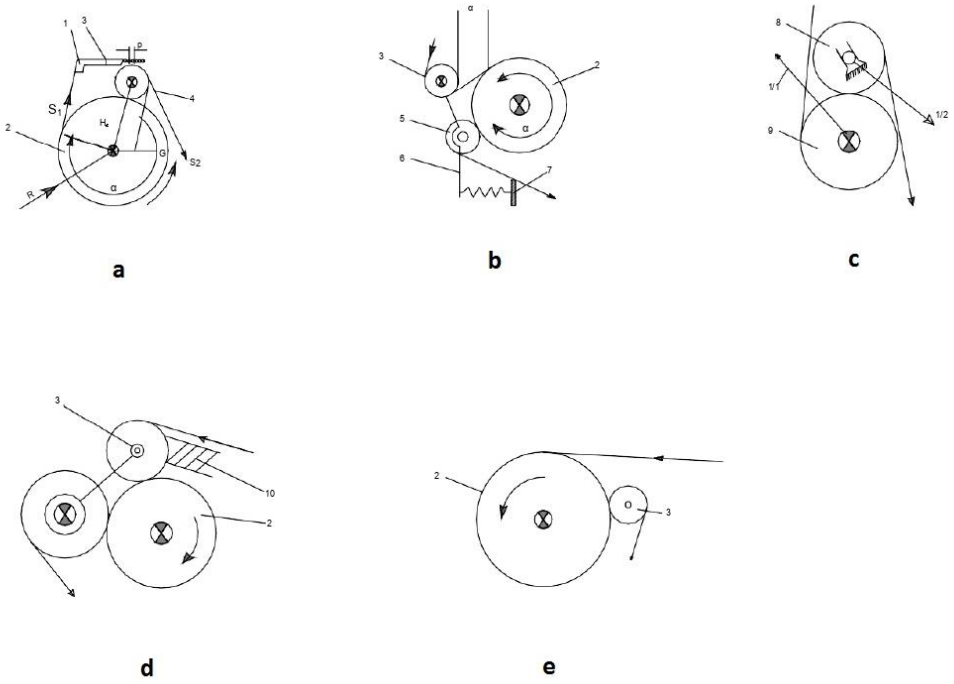

Figure 1: Fabric removal devices.

Analysis of the construction of a winding device.

Winding devices of weaving machines are divided into the following three groups:

Direct

Indirect

Roller

The structural scheme of devices for winding fabric is shown in figure 2.

In the direct action device (Fig. 2 a), the commodity roller *3* is driven directly by the roller *2*. In this case, the winding device is an integral part of the fabric removal device. The commodity roller rests on the slider *1* and is stretched to the valance by a spring or with the help of a load mounted on a linkage. The advantage of the direct action system is rather rigid and high quality winding of the fabric. The disadvantage of this system is the constant pressure of the felt on the fabric, as a result of which the fabric can be damaged. Therefore, the system is not used in the production of fabrics from chemical fibers. In this device, it is not possible to remove the commodity roller while the weaving machine is working. In addition to those mentioned above, in these devices, automation of the process of removing finished commodity rollers is very difficult. In practice, automation of the removal of finished commodity rollers becomes impossible [3-5].

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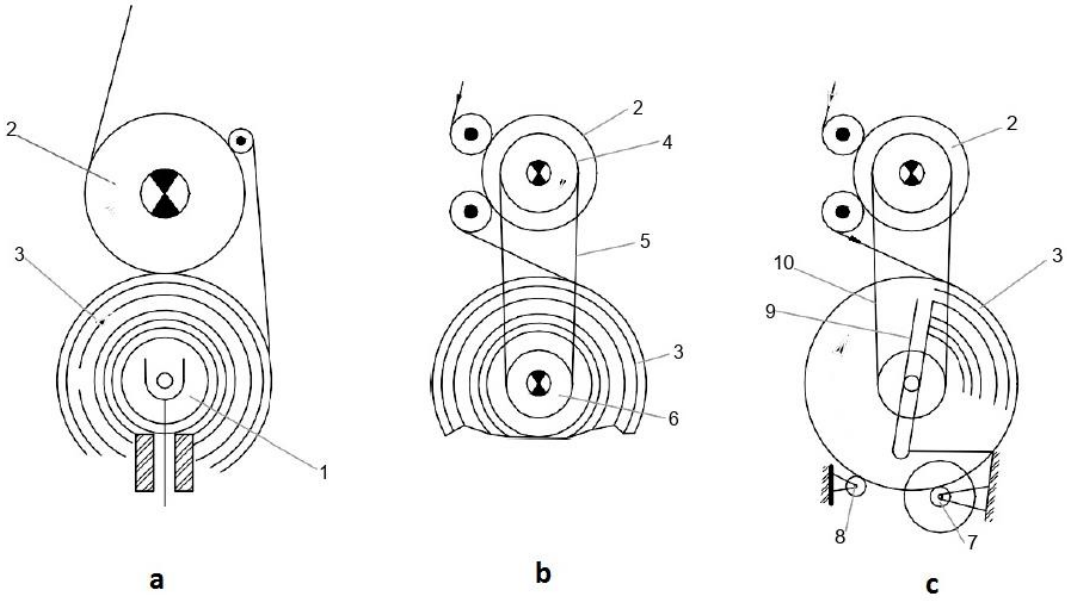

Figure 2: Winding devices.

The device of the continuous action system is a separate functional unit, which has a continuous drive using a belt *5* (Fig. 2 b) or gears from another main shaft. The drive of the device of the system of continuous action can also be discontinuous with the help of a ratchet and pawl. The transfer of movement to the commodity roller is shown in fig. 2 b. Here, the upper sprocket *4* is placed on the shaft of the valance *2*. The movement is transmitted by the roller chain *5* to the small sprocket *6* fixed on the shaft of the commodity roller *3*. Since the speed of the fabric retraction is constant, with an increase in the winding radius, the angular velocity of the commodity roller should decrease hyperbolically. To change the angular velocity, it is advisable to use a safety friction clutch installed between the sprocket *6* and the valance shaft *3*. Continuous systems are mainly used for the production of thin fabrics. The fabric tension decreases hyperbolically as the winding radius increases. This reduces the tension of the fabric and causes soft winding. This device provides the possibility of removing the commodity roller on the move of the machine. However, the fixed ends of the commodity rollers make it difficult to automate the process of removing the finished commodity rollers while the weaving machine is working [6-9].

The scheme of winding with the help of friction rollers is shown in fig. 2c. Here, the forging is mounted on two rollers *7* and *8*, of which one of them receives movement at a constant speed from the valance *2* through the chain drive *10* [10-12]. The axes of the commodity roller are guided by a slot in the backstage 9 or are held by levers that are fixed on the machine frame and have the ability to rotate about the fixing axis. With an increase in the winding radius, the mass of the forging increases, therefore, with a large diameter, the winding is quite rigid. A winding system of this type is used as a separate functional unit for the formation of forgings of large diameters up to *1 m*. On weaving machines of the TMM type and on Draper rapier looms, the rollers are wound by a system built on the machine [13-14].

Increasing the working width of the machine and the winding diameter leads to difficulties in transporting the finished fabric. The location of the commodity roller at the front of the machine requires a wide working aisle [15].

When winding with the help of friction rollers, the condition for removing the finished forging after cutting off on the move of the machine is ensured. This device has improved conditions for removing the finished forging automatically. Therefore, to create automated weaving factories in the constructions of weaving machines, it is advisable to ensure the winding of the fabric using friction rollers [16].

Conclusions and suggestions.

Based on the analysis of the construction of fabric removal mechanisms, it was found that the fabric removal device consists of three mechanisms:

Pulling roller (valance) with a rough surface

Commodity regulator

A winding device

Set the following basic conditions for removing fabric:

The fabric should not be damaged, so the felt must have an appropriate coating.

The fabric should not slide over the felt in order to maintain the specified weft density. When rubbing the fabric at its full width, the diameter of the roller also has the only value. The coefficient of friction depends not only on the material of the shaft coating, but also on the type of fiber, the weave of the fabric, on the condition of contact of these surfaces, which are determined by the static and dynamic parameters of the felt and the process of surfacing the weft thread to the edge of the fabric with a reed, i.e., from deformation and frequency natural fluctuations of the felt and the frequency of the beat of the weft thread to the edge of the fabric.

To ensure maintenance and limit time costs, as well as to automate the process of removing finished commodity rollers, conditions must be provided for removing the commodity roller while the machine is working. The fabric should not make a return movement after cutting and removing the finished roller.

The analysis found that the elasticity of the drive elements of the commodity regulator can lead to uneven rotation of the felt and, consequently, to the inconsistency of the density of the fabric in the weft. To ensure the rotation of the valance at a constant speed and constant density of the fabric along the weft, it is necessary to study the movement of the valance, taking into account the elasticity of the drive elements and the valance.

The scientific novelty of the article consists in the development and improvement of the mechanism of wrapping the fabrics of the looms to obtain new constructions on the loom, where:

The fabric will not be damaged;

The fabric will not slip on the weft to maintain the specified weave density;

After cutting and removing the finished roll, the fabric will not move back.

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SƏMƏRƏLİLİYİN ARTIRILMASI MƏQSƏDİ İLƏ TOXUCU MAŞINLARINDA MAL SARICI MExANİZMLƏRİN TƏDQİQATI

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XÜLASƏ

Dünyada yüngül sənayenin vəziyyəti hələ də ağırdır. Fiziki baxımdan ən mühüm tekstil məmulatlarının istehsalında azalma tendensiyası davam edir. Yüngül sənaye istehsalının azalmasının qaçılmaz nəticəsi potensialın aşağı səviyyədə istifadəsidir. Avadanlıqların əsas hissəsinin texniki-iqtisadi göstəriciləri müasir tələblərə cavab vermədiyindən, mövcud əsas fondların böyük hissəsinin gələcəkdə müvafiq yenidənqurma işləri aparılmadan istifadə edilməsi mümkün olmadığından, yüngül sənayedə vəziyyət daha da mürəkkəbləşir və rəqabətqabiliyyətli məhsulların istehsalı təmin edilir.

Son illərin beynəlxalq təcrübəsi göstərir ki, toxuculuq və yüngül sənaye üçün maşınqayırma böhrandan çıxmaq və gələcək inkişaf üçün yaxşı perspektivlərə malikdir. Bu sənayelər üçün texnologiyanın intensiv təkmilləşdirilməsi aşağıdakı əsas istiqamətlərdə həyata keçirilir:

- avadanlıqların məhsuldarlığının artırılması;
- maşınların ən qabaqcıl mikroprosessor idarəetmə və proseslərə nəzarət sistemləri ilə təchiz edilməsi;
- əmək tutumlu maşınlara texniki qulluq əməliyyatlarının robotlaşdırılması;
- müxtəlif emal olunmuş xammallar üçün avadanlıqların universallaşdırılması.

Toxuculuq maşınqayırmasının inkişaf konsepsiyasına və toxuculuq sənayesindəki mövcud iqtisadi vəziyyətə əsasən istehsalın təkmilləşdirilməsi üçün əsas istiqamətlər aşağıdakılardır:

- dəzgahların məhsuldarlığının artırılması, onların avtomatlaşdırma dərəcəsinin, etibarlılığının, erqonomikliyinin və keyfiyyətin yüksəldilməsi, habelə xammala qənaət edilməsi istiqamətində mənimsənilmiş istehsalın və kütləvi istehsal olunan avadanlığın müasirləşdirilməsi (təkmilləşdirilməsi);
- toxuculuq sənayesi müəssisələrində fəaliyyət göstərən avadanlığın ayrı-ayrı aqreqatların, modulların dəyişdirilməsi, maşın və aqreqatların avtomatlaşdırma və alətlərin idarə edilməsi ilə təchiz edilməsi yolu ilə modernləşdirilməsi.

Əhalinin toxuculuq və yüngül sənaye məhsullarına olan tələbatını ödəmək üçün müxtəlif çeşiddə parçaların istehsalının artırılması tələb olunur. İstehsal olunan parçaların keyfiyyəti dəzgahların mexanizmlərinin konstruksiyasından asılıdır. Toxuculuq maşınlarında istehsal olunan parçanın keyfiyyətinə təsir edən mexanizmlərdən biri də parça çekici mexanizmidir. Bu mexanizm üç cihazdan, bir dartma çarxından (valyan), mal tənzimləyicisindən və sarıyıcı qurğusundan ibarətdir.

Açar sözlər: yüngül sənaye, parça çekici mexanizmi, sarıyıcı qurğu, valyan, sürtünmə əmsalı.

ИССЛЕДОВАНИЕ МЕХАНИЗМА НАВИВАНИЯ ТКАНИ НА ТКАЦКИХ МАШИНАХ С ЦЕЛЬЮ ПОВЫШЕНИЯ ИХ ПРОИЗВОДИТЕЛЬНОСТИ

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РЕЗЮМЕ

Состояние лёгкой промышленности в мире по-прежнему остается сложным. Сохраняется тенденция спада производства важнейших видов текстильной продукции в натуральном выражении. Неизбежным следствием снижения объёма производства продукции лёгкой промышленности является низкий уровень использования производственных мощностей. Положение в лёгкой промышленности осложняется ещё и тем, что большая часть имеющихся основных фондов не может быть задействована и в будущем без соответствующей реконструкции, т. к. технико-экономические параметры основной части оборудования не отвечают современным требованиям и не обеспечивают выпуск конкурентно-способной продукции.

Международный опыт последних лет свидетельствует, что машиностроение для текстильной и легкой промышленности имеет неплохие перспективы выхода из кризиса и дальнейшего развития. Интенсивное совершенствование техники для этих отраслей осуществляется в следующих основных направлениях:

- повышение производительности оборудования;
- оснащение машин самыми современными микропроцессорными системами управления и контроля технологического процесса;
- роботизация трудоемких операций по обслуживанию машин;
- универсализация оборудования для различного перерабатываемого сырья.

Исходя из концепции развития текстильного машиностроения и сложившейся экономической ситуации в текстильной промышленности, основными направлениями совершенствования производства являются:

- модернизация (усовершенствование) освоенного производства и выпускаемого серийно оборудования в направлении повышения производительности машин, увеличения степени их автоматизации, надежности, эргономичности и качества изготовления, а также экономии сырья;
- модернизация действующего на предприятиях текстильной промышленности оборудования путем замены отдельных узлов, модулей, оснащение машин и агрегатов средствами автоматизации и приборного контроля.

Для обеспечения потребности населения на изделие текстильной и легкой промышленности, требуется увеличить выпуск тканей различного ассортимента. Качество выпускаемых тканей зависит от конструкции механизмов ткацких станков. Одним из механизмов, влияющих на качество ткани вырабатываемых на ткацких машинах, является механизм отвода ткани. Этот механизм состоит из трех устройств, оттягивающего валика (вальяна), товарного регулятора и навивающего устройства.

Ключевые слова: лёгкая промышленность, механизм отвода ткани, навивающее устройство, вальян, коэффициент трения.

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IMPROVING THE PERFORMANCE OF THE GAS LIFT VALVE SEAL

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ABSTRACT

Currently, gas lift valves are widely used in the gas industry to maintain pressure in wells. However, there are often problems with sealing valves, which leads to a loss of efficiency and increased energy consumption. Improving the operability of the sealing element of the gas lift valve will reduce the likelihood of gas leaks and increase the reliability and efficiency of the entire gas lift device. In addition, this will reduce the cost of repairing and replacing faulty sealing elements and improve the economic efficiency of gas production.
The sealing element of the gas lift valve plays a key role in ensuring reliable and efficient operation of this device. A malfunction of the sealing element can lead to a gas leak, which will entail significant financial losses and risks to the safety of personnel and the environment. Therefore, the urgency of improving the operability of the sealing element of the gas lift valve is to ensure the safe and reliable operation of oil and gas equipment, improve the economic efficiency of production and reduce financial losses of companies engaged in gas production and transportation.
The purpose of the work is to study the provision of a gas lift valve and a check valve with a flexible, sealing element and means to protect the element from deflection or destruction.
Keywords: gas lift valve**,** Bellows type, Valve sealing, Composite materials, Fluoroplast-4, Carbon fiber, Socket for the sealing.

The gas lift method of oil extraction is the process of oil extraction, which is carried out by using a mixture of gas and liquid in wells. The gas lift method is one of the most common and effective methods of oil extraction and is used in many places around the world. The basic principle of the gas lift method is to use gas to create a gas cushion that helps lift oil to the surface. To create this cushion, gas is injected into the well, which allows additional pressure to be created, which helps to raise the oil to the surface. The gas lift method is used for oil extraction from a great depth, where traditional methods of oil extraction may be less effective. During the operation of wells, various methods of reducing starting pressures can be used, based on reducing the density of products in the lifting column. The most effective use of starting gas lift valves. A gas lift valve is a device used in a gas lift well to control the flow of gas and liquid. It is important for the gas lift system, because it allows you to regulate the capacity of the well and maintain a stable pressure in the well. Well start-up is carried out using the so-called starting valves, and the gas input during normal operation of the lift is carried out through the so-called working valve. The whole variety of deep valves can be classified according to the following criteria:
1 As intended:
starting; working; end.
2 By design:
spring; bellows; combined.

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3 By the nature of the work:
normally open; normally closed.
4 By actuation pressure:
from the pressure in the annular space; from the pressure in the lift.
Bellows gas lift valve is one of the types of gas lift valves that is used in wells to regulate the flow of gas and liquid. The bellows is a sealed membrane made of a special material. It connects two chambers inside the valve and serves to control the flow of liquid and gas in the well. When the pressure in the upper chamber rises, the bellows expands, opening the way for liquid and gas to escape through the valve. When the pressure decreases, the bellows contracts and closes the way for the liquid and gas to exit.
The advantage of the bellows gas lift valve is its high reliability and durability. The bellows is made of a special material that is highly resistant to various operating conditions, such as high pressure, temperature and aggressive environments. In addition, the bellows valve does not require constant maintenance and can work for a long time without interruption.

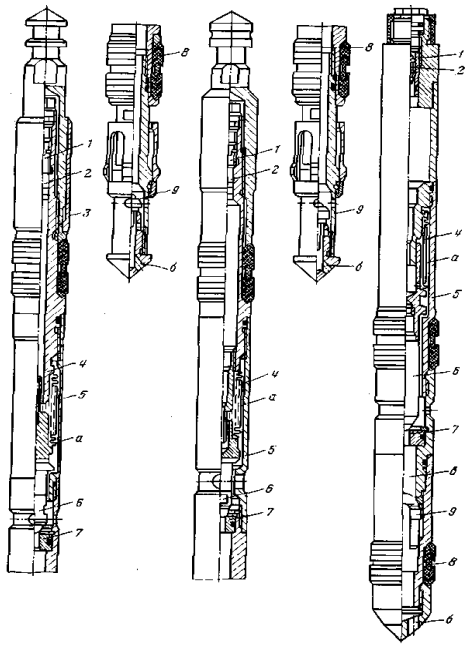

Figure 1: Bellows type gas lift valve

Bellows-type gas lift valves consist of a charging device, a bellows chamber, a rod-seat pair, a check valve and a device for fixing the valve in the borehole chamber.
The bellows chamber is charged with nitrogen through a spool. Bellows chamber is a sealed welded pressure vessel, the main working body of which is a metal multilayer bellows. The rod-seat pair is the shut-off device of the valve to which the gas flows through the windows of the pocket of the borehole chamber. The check valve is designed to prevent the flow of liquid from the lifting pipes into the annulus of the well. Bellows-type gas lift valves are divided into starting and working valves for their intended purpose. The control pressure for the starting valves is the gas pressure of the annular space of the well. Acting on the effective area of the bellows, the gas compresses it, as a result of which the rod rises, and the gas, opening the check valve, enters the

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lifting pipes. The number of valves to be installed depends on the gas pressure in the well and its depth. They are closed sequentially as the level in the annular space of the well decreases. The lowering of the level in the annulus of the well continues to the depth of the lower (working) valve.

The bellows—type gas lift valve seal is a device that ensures tightness of the connection between the valve body and the bellows, which is used to compensate for deformations. The seal usually consists of an O-ring and a bellows. The sealing ring is usually made of materials that have good resistance to aggressive environments and high temperatures. These can be various polymers, such as fluoroplastics, polyamides, polyethylene, polypropylene and others.

Valve sealing problems can occur for various reasons. Investigation of these reasons is an important step to improve the efficiency and reliability of gas lift equipment, as well as reduce the cost of its maintenance and repair. One of the main causes of problems with sealing valves is the wear of sealing elements. Sealing elements can wear out due to friction, loads, exposure to chemically aggressive media and high temperatures. The wear of the sealing elements can lead to gas leakage and reduce the efficiency of the gas lift device.

Creation of composite materials that consist of a combination of Fluoroplast-4 and carbon fiber. This can improve the performance and durability of the sealing element, since carbon fiber has high strength, and Fluoroplast-4 resists chemical attack well and has high temperature stability. However, such composite materials require additional research and testing to determine their optimal properties in specific operating conditions of gas lift valves.

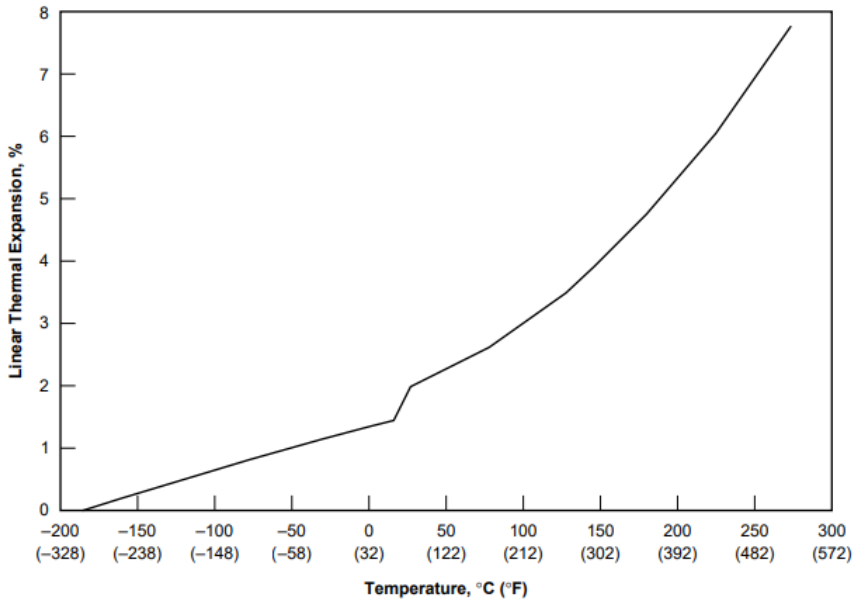

Figure 2: Graph of dependence termal expansion on temperature

Fluoroplast-4 (PTFE) has the following advantages:

1. Excellent chemical resistance
2. low coefficient of friction
3. excellent wear resistance
4. high temperature resistance

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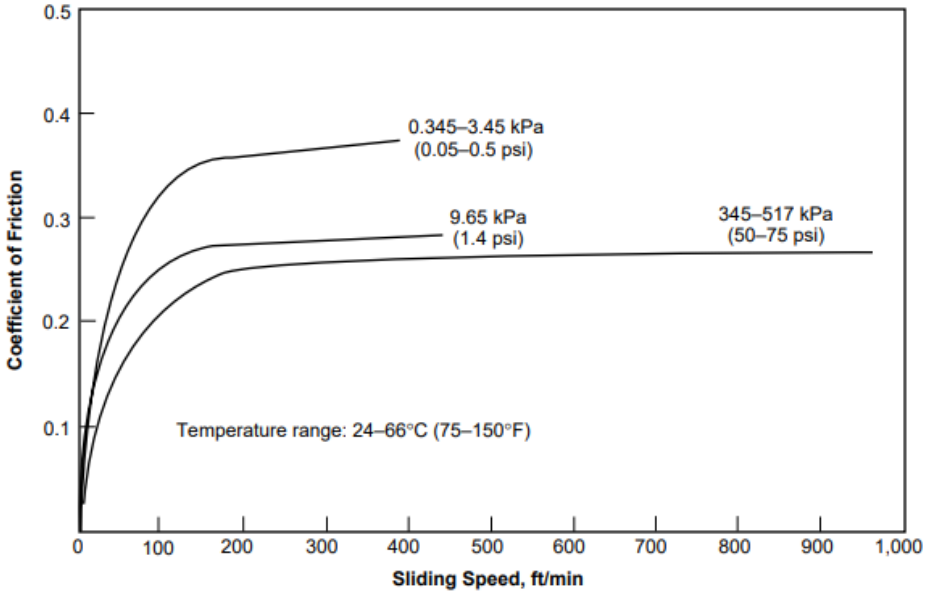

Figure 3: Graph of dependence coefficient of friction on silding speed

Some of the disadvantages of Fluoroplast-4:

1. poor mechanical strength
2. relatively high cost
3. poor electrical conductivity.

Carbon (C) also has its advantages:

1. high strength and rigidity
2. excellent wear resistance
3. low density.

Some of the disadvantages of carbon fiber:

1. poor chemical resistance
2. instability to high temperatures
3. high cost.

Combining Fluoroplast-4 with carbon fiber can help combine the advantages of both materials and eliminate their disadvantages. For example, the use of a carbon matrix with inclusions of Fluoroplast-4 can improve chemical resistance and reduce friction while maintaining high strength. However, such combined materials can be difficult to manufacture and have a high cost. The combination of Fluoroplast-4 and carbon as a composite material can be achieved by producing a composite using filling technology, where carbon particles are added to a matrix of Fluoroplast-4. Preparation of materials: Fluoroplast-4 and carbon fiber (usually in the form of powder or fibers). Mixing of Fluoroplast-4 and carbon fiber in the right ratio in accordance with the requirements of the project. Pressing the composite material into the desired shape and size. Heat treatment, which may include heating to a certain temperature and holding at this temperature for polymerization of Fluoroplast-4 and fusion of carbon particles with the matrix.
Schematic formation of graphite structure:

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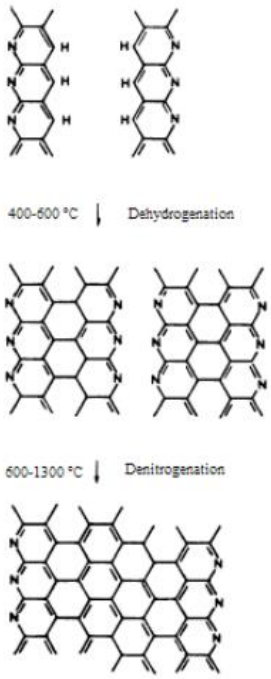

Figure 4: Graphite structure

Technical characteristics of the material:

- Tensile strength: from 50 to 200 MPa
- Coefficient of thermal expansion: from 2 to 10 microns/m*K
- Operating temperature range: -50 to +150 °C
- Density: from 1.6 to 2.0 g/cm3;
- Compressive strength: from 70 to 150 MPa
- Modulus of elasticity: from 5 to 15 GPa
- Coefficient of thermal expansion: from 1.5 to 2.5*10^-6 to^-1
- Degree of heat resistance: up to 250 degrees Celsius
- Chemical resistance: good

Depending on the type of composite materials connection, the shape of the socket for the sealing element will change. changing the design of the sealing ring and seal will increase the operability of the valve itself.

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Figure 4: Wireline gas lift valve

The sealing element in the gas lift valve is usually located on the spindle or on the axis of the gate. This part of the valve on which the sealing element is located is called the valve seat or seat seal. The valve seat is the surface on which the sealing element presses, ensuring the tightness of the valve when closing. Usually the valve seat is made of materials that have high wear resistance and corrosion resistance. It can be made either as a separate element or integrated into the valve body. The seat can be made from a variety of materials, depending on the specific requirements of the valve. Common materials used for valve seats include metals such as stainless steel, tungsten carbide, and nickel alloy, as well as ceramics and polymers. The choice of material depends on the fluid being pumped, the operating temperature and pressure, and the expected wear and corrosion resistance. The seat may be integral to the valve body, or it may be a separate component that can be replaced. In some cases, the seat may be designed as a replaceable cartridge that can be easily removed and replaced, simplifying maintenance and reducing downtime. The shape of the seat is critical to the performance of the valve. The seat must be machined to the correct shape and dimensions to ensure proper sealing and to avoid damage to the sealing element. Typically, the seat is a conical or spherical shape that matches the shape of the sealing element, creating a tight seal when the valve is closed. The angle of the cone or sphere can vary depending on the specific valve design.

In summary, the seat of a gas lift valve is an essential component that ensures proper sealing and safe operation of the valve. It can be made from a variety of materials and may be a separate component or integral to the valve body. The shape of the seat is critical to the performance of the valve, and it must be machined to precise dimensions to ensure proper sealing and avoid damage to the sealing element.

Conclusions

The main objectives of the work were to study the mechanical properties of such a combination of materials, as well as to determine the optimal parameters for obtaining composite materials with maximum strength and durability, which will improve the characteristics of the sealing elements of gas lift valves, which will lead to an increase in the operating time of the valve itself.

The results of the study showed that the combination of composite elements of fluoroplast-4 with carbon leads to an improvement in the mechanical properties of the material. In particular, it was found that the addition of carbon to fluoroplast-4 increases its strength and rigidity, as well as reduces the tendency to fracture due to fatigue. In addition, the resulting composite materials were resistant to high temperatures and chemical aggressive environments.

Thus, it can be concluded that the combination of composite elements of fluoroplast-4 with carbon is an effective way to obtain composite materials with high strength and durability. The results of the work can be used in various industries where high strength and stability of materials are required.

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ПОВЫШЕНИЕ РАБОТОСПОСОБНОСТИ УПЛОТНИТЕЛЯ ГАЗЛИФТНОГО КЛАПАНА

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РЕЗЮМЕ

В настоящее время газлифтные клапаны широко используются в газовой промышленности для поддержания давления в скважинах. Однако часто возникают проблемы с уплотнением клапанов, что приводит к потере эффективности и увеличению энергопотребления. Улучшение работоспособности уплотнительного элемента газлифтного клапана снизит вероятность утечек газа и повысит надежность и экономичность всего газлифтного устройства. Кроме того, это позволит снизить затраты на ремонт и замену неисправных уплотнительных элементов и повысить экономическую эффективность добычи газа.
Уплотнительный элемент газлифтного клапана играет ключевую роль в обеспечении надежной и эффективной работы этого устройства. Неисправность уплотнительного элемента может привести к утечке газа, что повлечет за собой значительные финансовые потери и риски для безопасности персонала и окружающей среды. Поэтому актуальность улучшения работоспособности уплотнительного элемента газлифтного клапана заключается в обеспечении безопасной и надежной работы нефтегазового оборудования, повышении экономической эффективности производства и снижении финансовых потерь компаний, занимающихся добычей и транспортировкой газа.
Целью работы является изучение обеспечения газлифтного клапана и обратного клапана гибким уплотнительным элементом и средствами защиты элемента от прогиба или разрушения.
Ключевые слова: Газлифтный клапан, сильфонный тип, Уплотнение клапана, композитные материалы, фторопласт-4, углеродное волокно, Гнездо для уплотнения.

QAZ QALDIRICI KLAPAN MÖHÜRÜNÜN İŞ QABİLİYYƏTİNİN ARTIRILMASI

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XÜLASƏ

Hal-hazırda qaz lift klapanlar qaz sənayesində quyuların təzyiqini qorumaq üçün geniş istifadə olunur. Bununla birlikdə, klapanların kipləndirmə ilə bağlı problemlər tez-tez baş verir, bu da səmərəliliyin itirilməsinə və enerji istehlakının artmasına səbəb olur. Qaz lift klapanının sızdırmazlıq elementinin işini yaxşılaşdırmaq qaz sızması ehtimalını azaldacaq və bütün qaz lift cihazının etibarlılığını və səmərəliliyini artıracaqdır. Bundan əlavə, bu, nasaz sızdırmazlıq elementlərinin təmiri və dəyişdirilməsi xərclərini azaldacaq və qaz hasilatının iqtisadi səmərəliliyini artıracaqdır.
Qaz lift klapanlar sızdırmazlıq elementi bu cihazın etibarlı və səmərəli işləməsində əsas rol oynayır. Sızdırmazlıq elementinin nasazlığı qaz sızmasına səbəb ola bilər ki, bu da işçilərin və ətraf mühitin təhlükəsizliyi üçün əhəmiyyətli maliyyə itkiləri və risklərə səbəb ola bilər. Buna görə qaz lift klapanları sızdırmazlıq elementinin iş qabiliyyətinin yaxşılaşdırılmasının aktuallığı

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neft və qaz avadanlıqlarının təhlükəsiz və etibarlı işləməsini təmin etmək, istehsalın iqtisadi səmərəliliyini artırmaq və qaz hasilatı və nəqli ilə məşğul olan şirkətlərin maliyyə itkilərini azaltmaqdır.
İşin məqsədi qaz qaldırıcı klapan və yoxlama klapanının çevik sızdırmazlıq elementi və elementi əyilmədən və ya məhv olmaqdan qorumaq üçün vasitələrlə təmin edilməsini öyrənməkdir.
Açar sözlər: qaz Qaldırıcı klapan, körük növü, klapan kipləndiricisi, kompozit materiallar, flüoroplast-4, karbon lifi, sızdırmazlıq yuvası.

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TUBING HANGER INVESTIGATE OF LOADING

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ABSTRACT

In this article, the failures of tube hangers made from UNS N07718 are discussed. An arrangement known as a tubing hanger may be found in wells that produce either oil or gas. It is positioned in the upper tubing head's bowl after it has been installed. The tubing is held in place by this, and a main annulus seal is created between tubing also the production casing. This holds the tubing in place, and at the same time, it creates a primary annulus seal between tubing also production casing. When compared to odd component in wellhead system, tubing hangers are available in a broader range of styles and sizes than any other option. Tubing hangers made of UNS N07718 are often used in the installation process of sour service oil and gas wells that operate under high pressure and also high temperatures. Afterwards more than 10 years of service, it was only recently found that the tubing hanger made of UNS N07718 had failed in sour wells. Failures of the tubing hanger will inference in substantial production delays as well as high workover expenses. The purpose of this research is to demonstrate the failure mechanism of tubing hanger furthermore its ramifications on existing wells that were erected with material that is comparable to what was used here. In order to establish what caused the failure, each and every exposure that was brought on by well intervention efforts was evaluated. The manner of failure of stringer head suspension was researched, as was its influence on already existing wells that had been erected with materials that were comparable.
Keywords: tubing head, tubing hanger, tubing thread, back pressure valve profile, landing shoulder, snap ring, running thread.

Introduction. UNS N07718 is a nickel-based, high-strength precipitation-hardened steel that is widely used in the Oil & Gas industry for essential load-bearing wellhead and borehole components like tubing hangers, producers, safety valve elements, etc. in extremely sour surroundings in which corrosion resistance is very important. UNS N07718 tubing hangers are currently being used on a number of high-pressure, high-temperature wells for oil and gas in sour service. Many of these wells have been finished before API6A 728 came out in 2004, so they might not meet the latest API6A CTA requirements.
Relevance. After further than ten years of use, a tubing hanger made of UNS N07718 was recently found to have broken within one of the sour wells. If a tubing hanger fails, it will delay production and cost a lot of money to fix. The purpose of this research is to show how the tubing hanger fails and what that means for wells that already have similar parts installed. All well intervention activities, such as integrity tests, hydraulic fracturing, coiled tubing operations, etc.,

have been looked at to find out why they failed. Microstructural analysis with an optical microscope and a scanning electron microscopy (SEM) showed that the material had several bad metallurgical phases, such as acicular and laves phases, which caused the breakdown of the tubing hanger. It was found that the material didn't meet the current requirements listed in API 6A CRA and its predecessor, API 6A 718.

Objective. Tubing hanger is indeed a part of a well that is used to make oil or gas. It is put in a tubing head in the top bowl. It also holds the tubing in place and seals the annulus between both the tubing and the production casing.

Tubing Hangers: PARVEEN has four main kinds of tubing hangers. These are the Mandrel Type (PTHSM), the Wrap Around Type (PTHSW), the Extended Neck Type (PTHSE), and the Dual Split Type (PTHDE). We also offer the Elongated Neck Category with Control Lines (PTHSCL), the Dual Torn Category with Control Lines (PTHDCL), the Mandrel Type with Metal-to-Metal Seals (PTHTSM), and the Mandrel Type with something like a Perpetual Control Line and Metal-to-Metal Seals (PTHTSMM).

In the structure of the tubing hanger, thrust caps are provided in two upper crosses in order to prevent casing columns from elongating from high temperature stresses at a significant length of the uncontaminated part of casing columns. In the absence of thrust bundles, as a result of the extension of the pipe column, the sealing on the suspension is broken, which in some cases leads to disturbance of the wellhead equipment. After suspension of the tube casing columns, the column head receives the axial stresses and, in addition, each cross is receiving from below the internal pressure of the well fluid or the pressure of the pressure of the pressure pressure of the pressurization on the tightness.

The tubing head is under the influence of temperature voltage, which is transmitted to the sealing cuffs and studs and at high values it weakens the connections between the crosses. When circulating, the drilling fluid consistently washes the internal surface of the crosses and the head housing, subjecting them to hydraulic erosion.

Tubing hangers come in more sizes and shapes compared to any other single part of the wellhead system. They must be set up so that they can meet the requirements of both a simple completion and the more complicated completion needs of oil and gas wells in the 21st century.

Before the BOP is taken off, the Tubing Hanger controls the well bore.

Holds the manufacturing tubing in place inside the well.

Gives the sequence of tubing that is being suspended its primary annulus seal.

Could be made for a single string of tubing or for numerous strings.

Could be made in different ways, such as with DHCV ports, Gas Injection ports, Optical Fiber Equipment ports, and numerous ESP Penetrator profiles, but not limited to these.

Tubing hanger has a long neck and is made of a threaded mandrel. This hanger's neck has "S"-shaped seals that hold the tubing head mounting kit in place. This hanger can be set up with an interference type "S" shield or compression packing mostly on body to make an annular seal. Effectively control screws are employed to both power this packing and keep the hanger from falling out of tubing head bowl.

The UNSN07718 type tubing hanger also refers to a type of tubing hanger with a threaded mandrel this is used for more difficult finishing applications. The tubing hanger legislature has a long neck that is encased at the top by a trimmed metal seal (TMS). The TC-1A-TMS also has

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metal-to-metal closed loop feedback line fittings that stop leaks in the SCSSSV line from going through places they shouldn't.
These have OD seals on prolonged neck for testing, and the tubing head doesn't need to be aligned.
Could be either a compression seal or an interference seal.
Could have XEMS and/or TMS metal-to-metal seals.
Could have high-quality tubing or landing threads.
Could have special ports for instrument or control lines.
When working with electrically powered submersible pumps, often known as tubing hanger is indeed a necessary accessory. The hanger has openings in it, and one of those openings is meant to take in a production line tubing string. The pump is powered by an electrical supply cord, which will fit into the second port that has been specifically built for it. Designs have been finished that allow for heat trace cabling in addition to downhole controlling valves and fiber optic instrumentation lines. These designs have also been implemented.
Tubing hanger should indeed be built using materials that are appropriate to withstand the sulfide tension cracking. The NACE Standard with number MR-01-75 provides more clarification on this matter. The valve bodies have to be manufactured out of stainless steel, and the gates, seals, and packing materials ought to be made out of substances that really are compatible with both the acidic environment and the amines that are employed for inhibition. In instances of wells with high pressure as well as located in sensitive environmental zones, a surface circulation system should be developed at wellheads. In the event that the gas leak takes place, this will give a means of regulating the wellhead from a distant location. A such device should have three different lines. The lines could be used to flow liquids into the well for reasons of lowering of tension and to destroy the wells. An inlet for the pump should be created behind the production choke. In addition to that, it need to be inserted through into casing annulus or the injection string. Monitoring of the surface system should include looking for corrosion information, checking the safety status, and gathering wellhead data. This should be done out utilizing a planned manual examination and electronically. Circulation and injected pressure, pneumatic power source, the state of the injection pump, and temperatures are all examples of important data that should be monitored.
Autoclave needle tubing and valves made of Alloy C-276 should be installed in the tubing hanger. Metal one-piece seats and gates are recommended for use in the production of tubing hangers. Stems, gates, and other internal valve parts may be made from Alloy 718 that has been heated. This is due to its excellent strength and resistance to corrosion. Alloy 718 should be used to make the hangers. They need to be hermetically sealed at the bottom and the top with a plasticised steel to steel seal.
Leaks in this system should be kept to a minimum as much as possible throughout the well's service life, which should guide the design philosophy here. As a result, the tubing's seals may be kept in a constant, unmoving position throughout the whole of manufacturing and normal operation. Downhole sealing of the tubing casing annular using a polishing bore receptacle system is recommended for safe and dependable operations. Each component of the system should have a smooth, polished bore. In addition to the locator, the completion tubing should contain a set of elastomer seals. Alloy C-276 should be used to make the polished bore receptacle. This should

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improve the item's durability and resistance to corrosion. When it comes to completing components, this system is among the most trustworthy.

The coiled tubing unit must be installed upwind of the well. To prevent dangerous movement, the device should be adequately secured. When running underbalanced, it is recommended to think about a pumping cross and a second ram sealer underneath the pump cross. Wellbore fluids should never be returned to the coiled tubing section. For more than two decades, coil tubing has indeed been employed in sour well settings. When compared to other options in oil field operations, developments in coil tubing technology to make it a more cost-effective option. This is the outcome of studies on the behavior of coiled tubing while subjected to sour down-hole environments. The parameters, limits, new advancements, testing, and implementations of CT are examined in this study.

The buy specification is the core of the management system, as well as the beginning point in time. At this stage, the sorted strings are deemed to be suitable for use within the sour wells. Strings generated expressly for sour service are expected to be less vulnerable to catastrophic sour deterioration, thus the standards are also significant. In general, two kinds of strings are bought for work-over procedures. The first is a nontaper 400 m standard string, which may be used for a variety of applications including acidic stimulation, grinding operations, wellbore drain cleaning, gas lifting, cementing activities, and fishing. The tapering string is the second. Different purchase standards are advised for each of them. Following scientific research, the following pipe buying standards were released onto the market. The maximum permitted fatigue for regular strings is 70%, whereas fatigue for taper strings is up to 60%. Current industry regulations for Sour fatigue permit up to 20% for conventional strings, but 48% for tapered strings. When utilizing standard string, the typical need for sour tasks is 19%, but taper string requires 87%. Corrosion fatigue requirements for conventional string are 25%, whereas taper needs are 40%. The required standard for acid pumped Amit M, Almodaris M (2016) Hazardous Practices in Sour Gas Well Drilling and Completion.

There are issues related with sour wells, including as corrosion induced by atmospheric co2, hydrogen sulfide, scale precipitation, and the SSC. The selection of appropriate materials for wellheads, tubulars, and surface facilities should be utilized to resolve problems created by SSC. In production wells, the combination of atmospheric co2 and free water results in a low pH environment. This environment produces exceedingly corrosive conditions. The existence of atmospheric co2 also produces erosion phenomena resulting from the development of high pressures. The erosion is caused by the high velocities that result from the high pressure output. This issue may be resolved by using inhibitors and interior coatings. In addition, interior coatings may give further protection in hot and acidic situations. However, coatings should be used along with effective programs to stop corrosion. In such wells, water-dispersible and oil-soluble systems should be used as inhibitors. Oil-soluble systems are highly wanted because they provide a more durable film than other systems. A lipid-soluble amine may be combined with hydrocarbon carriers.Developing high H2S fields isn’t a new thing. It is resourceful to learn from peer experiences around the world. This section aims to provide a couple of cases and present the challenges faced and actions taken.

Conclusion

This study's purpose is to describe the failure manner of tubing hanger as well as its consequences for existing wells constructed with comparable materials. All exposures resulting from well

intervention activities such as (integrity testing, fracturing, coiled tubing operations, etcetera.) have been evaluated to identify the reason of failure. Several adverse metallurgical phases, including as acicular and laves phases, are included in the material and have caused to the collapse of the tubing hanger, as determined by scanning electron and optical microscopy (SEM) examinations. It was determined that the material did not fulfill current API per round CRA and predecessor API 6A 718 criteria.

Reference

1. The Tubing Hanger ensures that the well bore is under control before the BOP is removed. Maintains the manufacturing tubing in a suspended position inside the well bore. This component is responsible for providing the principal annulus seal on that string of tubing that is being hung. http://sentrywellhead.com/wo-content/uploads/2017/02/Sentry-Wellhead-Catalog.pdf
2. The annular seal is activated by a lock screw and is unaffected by the weight of the tube. Down hole command (DHCV) lines are isolated thanks to two seals located on that tubing hanger neck.
globalsupplyline.com.au/wp-content/uploads/2014/10/Wellhead-catalogue-xmas-tree-valves-r.pdf
3. Hangers developed for tubing are of the threaded mandrel type and have a load shoulder angled at 45 degrees, an expanded neck, tonging room, and BPV preparation. wellheads-christmas-trees-components.pdf(exal-technology.com)
4. Tubing hangers and tubing heads that are part of the TC series are available.
Hangers for tubing that are part of the TC series.
conventional-wellhead-brochure digital.pdf (technipfme.com)
5. Tubing hanger is load-bearing equipment that are passed through the blowout preventer. They are mounted in the upper bowl of the tubing head, where they are installed (BOP). Tubing hangers are used to provide support for the tubing string, which is typically located inside of the tubing head. Casing & tubing hangers - Acteon

KƏMƏR BAŞLIĞININ ASQISININ YÜKLƏNMƏYƏ TƏDQİQİ

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XÜLASƏ

Bu məqalədə UNS N07718-dən hazırlanmış kəmər başlığının asqılarının nasazlıqlarından bəhs edir. Kəmər başlığının asqısı təyinatına uyğun olaraq kəmər başlığının üst tərəfində yerləşdirilir və

tənzimləmə neft və ya qaz hasil edən quyularda mütəmadi olaraq istifadə edilir. Quraşdırıldıqdan sonra o, adəti üzrə kəmər başlığının qabına yerləşdirilir. Beləliklə, kəmər başlığı yerində saxlanılır və kəmər başlığı ilə istehsal korpusu arasında əsas halqa yaradılır. Bu, kəmər başlığının asqısını yerində saxlayır və həmçinin kəmər başlığı arasında əsas halqa yaratmağa xidmət edir. Kəmər başlığı sistemindəki tək komponentlə müqayisədə, kəmər başlığının asqıları hər hansı digər seçimdən daha geniş növlərdə və ölçülərdə mövcuddur. UNS N07718-dən hazırlanmış kəmər başlığının asılqanları ümumiyyətlə yüksək təzyiq və yüksək temperatur altında işləyən turşudan mühavizəli icrada xidmət neft və qaz quyularının quraşdırılması prosesində istifadə olunur. Bundan əlavə, UNS N07718 kəmər başlığının asqısı daha tələbkar olan tətbiqləri bitirmək üçün istifadə olunan yivli mandrel tipli kəmər başlığının asqısıdır. 10 ildən çox xidmət göstərdikdən sonra, kükürdlü korroziyaya uğradıcı neft quyularında UNS N07718-dən hazırlanmış kəmər başlığının asılqanının nasaz olduğu müəyyən edildi. Kəmər başlığının asqılarının nasazlığı əhəmiyyətli dərəcədə istehsal gecikmələri və yüksək biznes faiz xərcləri ilə nəticələnəcək. Bu tipli kəmər başlığının asqısının uzun müddət istismarını davam etdirə bilməsi üçün müəyyən profilaftik tədbirlər görmək zəruri və məqsədə uyğundur. Bu tədqiqatın məqsədi kəmər başlığının asqısının nasazlıq mexanizmini və onun burada istifadə olunan materiala oxşar materialla tikilmiş mövcud quyular üçün təsirlərini nümayiş etdirməkdir. Uğursuzluğa nəyin səbəb olduğunu müəyyən etmək üçün yaxşı müdaxilə səyləri ilə baş verən hər bir məruz qalma qiymətləndirilməlidir. Kəmər başlığının asqının pisləşməsinin və onun oxşar materiallarla tikilmiş mövcud quyulara təsirinin araşdırılmasıdır.

Açar sözlər: kəmər başlığı, kəmər başlığının asqısı, quyunun lüləsi, paker qurğusu.

ИССЛЕДОВАНИЕ НАГРУЗКИ НА ПОДВЕСКУ КОЛОННОЙ ГОЛОВКИ

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РЕЗЮМЕ

В этой статье рассматриваются неисправности подвесок колонных головок, изготовленных из UNS N07718. Подвеска колонных головок размещается поверх головки колон в соответствии с ее назначением, и такое расположение обычно используется в нефтяных или газовых скважинах. После установки он, как обычно, размещается в лоток колонных головок. Таким образом колонная головка удерживается на месте и создается основное кольцо между колонной головкой и эксплуатационной колонной. Это удерживает подвеску колонных головок на месте, а также служит для создания основного кольца между

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колонных головок. По сравнению с одним компонентом в системе колонных головок, подвеска колонных головок доступны в более широком ассортименте и размерах, чем любой другой вариант. Подвески для насосно-компрессорных труб, изготовленные из UNS N07718, обычно используются в процессе установки нефтяных и газовых скважин в кислотозащитных условиях, работающих под высоким давлением и высокой температурой. Кроме того, UNS N07718 представляет собой подвеску с резьбовым стержнем, используемую для выполнения более сложных задач. После более чем 10 лет эксплуатации было обнаружено, что подвески колонных головок UNS N07718, вышла из строя в нефтяных скважинах из-за коррозии серы. Выход из строя подвеска колонных головок , приведет к значительным задержкам производства и высоким затратам на участие в бизнесе. Необходимо и целесообразно принимать определенные профилактические меры, чтобы подвеска данного типа колонных головок могла продолжать свою работу в течение длительного времени. Целью данного исследования является демонстрация неисправности механизма подвески колонных головок и его последствия для существующих скважин, построенных из материала, аналогичного используемому материалу. Каждое воздействие, которое происходит, должно быть оценено с надлежащими усилиями по вмешательству, чтобы определить, что вызвало сбой. Это исследование неисправности подвески колонных головок и его влияния на существующие скважины, построенные из аналогичных материалов.
Ключевые слова: гидромеханический пакер, уплотнительный элемент, ствол скважины, устройство пакера.

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INVESTIGATION OF THE ENERGY CHARACTERISTICS OF CENTRIFUGAL PUMPS

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ABSTRACT

A hydraulic device that is used to suck up liquid, move it under pressure or pump it, is called a pump. As a rule, any movement of a liquid by similar aggregates is carried out due to the transfer of potential or kinetic energy to it. Depending on the technical indicators, different types of pumps are used. At the same time, they differ in efficiency, power, volumes of fluid pumped per unit time, maximum head and resulting pressure.

The most used group of pumps are vane pumps. Their distinctive feature is the impeller rotating in a fixed housing, equipped with blades. Depending on the warehouse of the impeller and the conditions for moving fluid through it, vane pumps are divided into centrifugal and vortex.

With a centrifugal pump, liquid is supplied due to the centrifugal force that appears when the impeller rotates. She is carried away by the blades and, under the action of centrifugal force, moves from the middle of the wheel to the edges along the blades. The blades of the impellers are bent in the direction of rotation backwards. The number of blades is usually from 6 to 8 pieces. But special pumps for impure liquids, in order to increase the cross section of the channels in the wheel, are installed with a smaller number of blades from 2 to 4 pieces.

Centrifugal pumps are usually installed above the liquid level in the receiving tank, so they must be filled before use. The pump is filled with a check valve on the suction line through the filling funnel until the gas is completely expelled from the suction pipeline and the pump housing. In the absence of a check valve, for filling, air is forced out of the pump housing with the valve closed by a special vacuum pump. The same is done when filling large pumps. Centrifugal pumps are characterized by a rather high efficiency, compactness and durability of use.

Based on the numerical modeling of hydrodynamic processes, a substantiation of adjustment of the design of the working wheels of centrifugal pumps is given. Mathematical modeling of the fluid flow in the running part of the centrifugal pump is performed. The results of the CFD calculation are analyzed, after which an experimental work wheel is created, and its tests are carried out. There is a process of comparing a serial and experimental pump.

Keywords: Centrifugal pumps, numerical modeling, mathematical model, energy characteristics, hydrodynamic processes, dynamic characteristics, power engineering, working wheel, working fluid, working wheel vanes.

Relevance of the topic: Currently, special attention is paid to energy supply. Actual is to increase the efficiency of pumping equipment. Environmental friendliness and energy consumption are indicators of the quality of the pumping unit, formulated by the European Association of Pump Manufacturers (Europump) in the Ecopump program [1].

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In the existing methods for designing centrifugal pumps, the calculation of the geometric parameters of the flow section of the flow part of the impeller is carried out using the numerical value of the pumped medium supply without taking into account the rotor speed. At the same time, to ensure the minimization of hydraulic losses, the principle of a smooth change in the speed of the translational movement of the pumped medium is implemented, starting from the initial section of the pump inlet pipe. Since the beginning of the design of industrial pumps (since the 13th century), these recommendations have been classic, underlying all known methods [2,3,4].
The study of the flow of the pumped medium in the flow part of the pump using modern computing tools and mathematical modeling methods [5,6,7] revealed its complex vortex nature. As an example, Figure 1 shows the results of a numerical calculation of the total pressure spectrum, pressure fields in the flow path in the optimal mode of a mass-produced centrifugal chemical pump XPO 1000/34 (8).

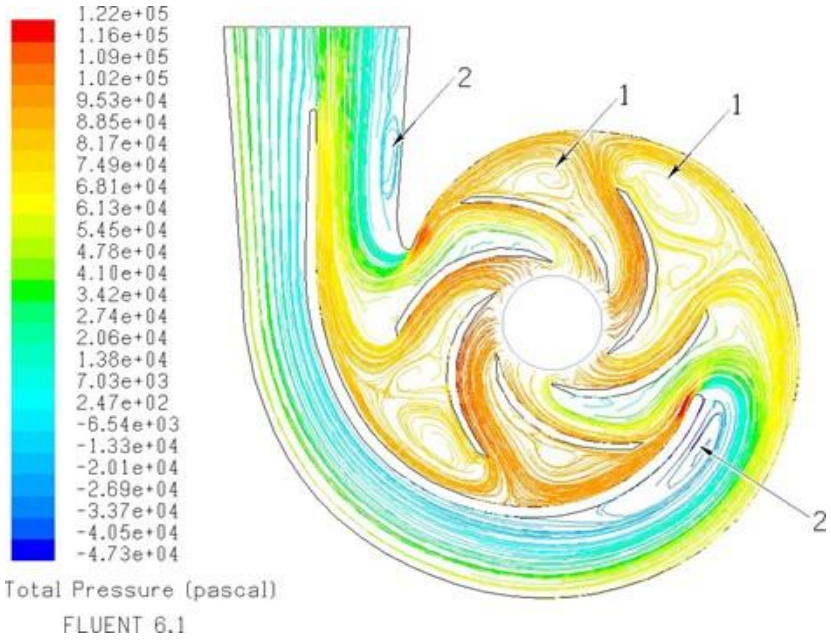

Figure 1: Total pressure spectrum at optimal operation of the XPO 1000/34 pump:
1 - whirling motion; 2 – backflows

The purpose of the work. Study of the performance of centrifugal pumps, their energy characteristics and hydrodynamic performance.
Research definition methodology. The simulation of fluid flow in a centrifugal pump was carried out using the numerical solution of the Navier-Stokes differential equations [9]. For the solution, the finite element method was used, which is implemented in computational fluid dynamics (CFD) programs, such as ANSYS CFX, FLUENT. The blade system model was built in the Unigraphics program, after which it was imported into the ANSYS program, where the calculation model was finalized and built using a regular rectangular grid. When constructing a computational grid. When constructing the computational grid, the following conditions were met: automatic partitioning by means of the ANSYS program; finite element type (FE) – PLANE 182; total number - 1885 finite elements; mesh thickening along the boundaries of the blades and body was not carried out. The flow calculation was carried out in the CFD package FLUENT.

The pump impeller rotates at a constant angular velocity of 103 rad/s. At the pump inlet, the value of the absolute flow velocity was set to 3.84 m/s, which corresponds to the optimal operating mode Q_{opt}. The temperature of the liquid medium at the inlet was assumed to be 16°C (286 K), the properties of the liquid medium corresponded to water with a density of 998 kg/m^3. The hydraulic diameter at the inlet and outlet was assumed to be D_r=0.608 m. The working medium was assumed to be incompressible, the flow regime was turbulent. The standard k-epsilon (k-ε) turbulence model was used in the calculation. To obtain a solution, 100 iterations were set, convergence was obtained at the 78th iteration. The calculation time was about 1,5 min.

Analysis of the simulation results shows the formation of reverse flows of the pumped medium from the spiral collector to the impeller and the formation of its circular vortex movement directly in the flow path, not participating in the flow rate, which occupies almost the entire space of the flow path. The main flow moves around the vortices and occupies only a part of the channel volume, which leads to large hydraulic losses. This can be explained by the fact that the flow path of a classically designed impeller is significantly over-expanded for the volume of the pumped medium.

If you pay attention to the fact that the impeller at a rotor speed of n = 3000 rpm makes 50 revolutions per second, then we can state that in one revolution only 1/50 of the total flow of the pumped medium passes through the impeller. This can explain the revealed translational motion of the pumped medium only in a narrow layer along the profiled blade (Figure 1).

Table 1: The given parameters of the experimental pump and AX 25/504

№	Pump delivery, m^3/h	Pump head, m		Pump efficiency, %		Pump power, kW	
		EP	AX	EP	AX	EP	AX
1	0,000	58,63	54,00	0,00	0,00	4,72	6,70
2	5,000	58,50	55,00	14,00	12,00	5,69	7,15
3	10,000	58,50	55,00	25,50	21,60	6,25	7,70
4	15,000	58,50	54,10	34,00	29,90	7,03	8,15
5	20,000	58,50	52,40	41,00	35,60	7,77	8,65
6	25,000	58,20	50,00	44,00	40,00	9,01	9,10
7	30,000	56	46,10	45,50	42,50	10,06	9,60
8	35,000	53,80	42,00	46,00	43,00	11,15	10,10
9	39,000	51,95	37,90	47,00	42,00	11,74	10,50
10	40,500	50,90		47,23		11,87	
11	45,500	47,17		46,22		12,62	
12	50,000	41,53		41,51		13,60	
13	50,000	38,12		37,10		13,97	
14	51,000	31,85		29,79		14,82	
15	53,000	27,23		26,18		14,99	
16	53,000	25,92		24,79		15,07	
17	53,000	20,71		18,89		15,80	
Rotation frequency of electric motor n=3000 rmp. EP – experimental pump; AX – serial pump AX 25/50							

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To test a new approach to the design of the flow path, an experimental impeller of a centrifugal pump was designed, manufactured and tested. The geometry of the flow part of the wheel had two channels of constant cross section with a total area of 2×10×30=600 mm^2. The results of tests of the prototype sample of the experimental pump are presented in the Table 1 and in Figure 2. Also in Figure 2 for comparison are the results of hydraulic tests of a serial chemical pump AX 25/50 (Q=25 m^3/h, H=50 m) of traditional design.

Comparison of the test results shows that the efficiency of the experimental pump is higher than the efficiency of the serial pump by ~2...4%. This can be explained by the realized high value of the hydraulic efficiency of the experimental pump due to a decrease in hydraulic losses due to vortex formation. At the same time, it should be noted that the maximum flow rate of the experimental pump was ~50 m^3/h and its limitation is associated with the development of cavitation phenomena in the "throat" of the pump outlet diffuser due to the implementation of the maximum flow rate.

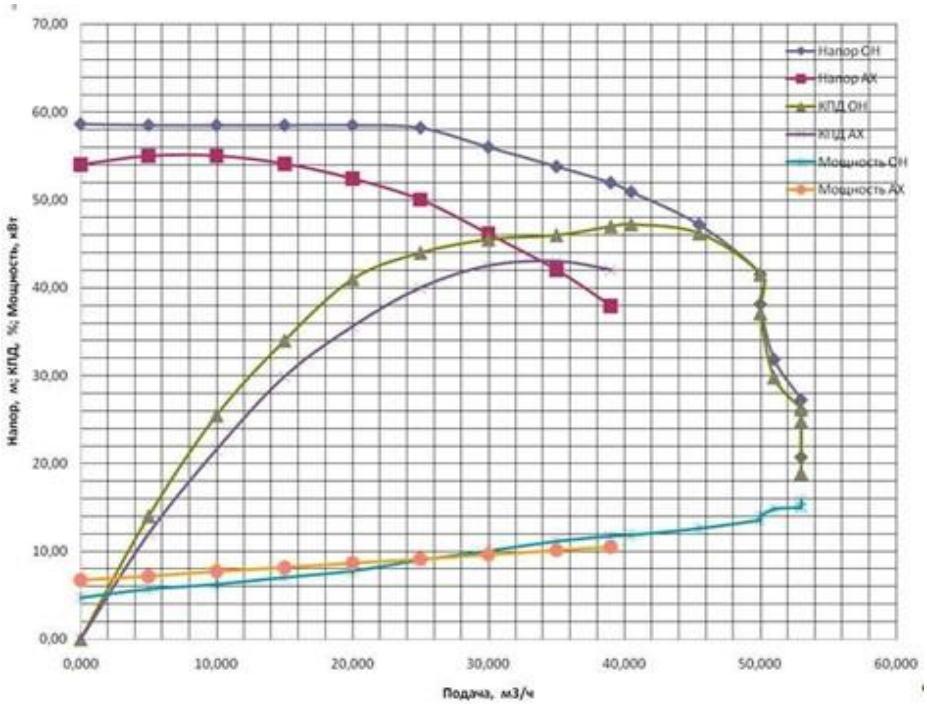

Figure 2: Energy characteristics of the experimental pump and AX 25/50

Conclusions of the research results.

1) The test results of the experimental pump confirm the feasibility of changing the traditional approach to designing the flow part of the pump impeller and a significant reduction in the area of the flow section of its flow part.

2) The reserve for increasing the efficiency of a centrifugal pump is the minimization of hydraulic losses by optimizing the flow path of the impeller and implementing an irrotational flow of the pumped medium in it.

3) To determine practical recommendations for optimizing the geometry of the flow path of the impeller, it is necessary to conduct additional computational and experimental studies.

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ИССЛЕДОВАНИЕ ЭНЕРГЕТИЧЕСКИХ ХАРАКТЕРИСТИК ЦЕНТРОБЕЖНЫХ НАСОСОВ

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РЕЗЮМЕ

Гидравлическая установка, которая используется для всасывания жидкости, её напорного перемещения или нагнетания, именуется насосом. Как правило, любое передвижение жидкости аналогичными агрегатами осуществляется благодаря передачи ей потенциальной или кинетической энергии. В зависимости от технических показателей и используются разные виды насосов. При этом они различаются коэффициентом полезного действия, мощностью, объемами

перекачиваемой за единицу времени жидкости, максимальным напором и возникающим давлением.

Самой используемой группой насосов являются лопастные насосы. Отличительной спецификой их является вращающееся в недвижном корпусе рабочее колесо, оснащенное лопатками. В зависимости от склада рабочего колеса и условий продвижения через него жидкости лопастные насосы делятся на центробежные и вихревые.

Центробежным насосом жидкость подается благодаря центробежной силы, появляющейся при кручении рабочего колеса. Она увлекается лопатками и под действием центробежной силы передвигается от середины колеса к краям вдоль лопаток. Лопатки рабочих колес согнуты по ходу вращения назад. Количество лопаток обычно составляет от 6 до 8 штук. Но особые насосы для не чистых жидкостей с целью повышения сечения каналов в колесе устанавливают с меньшим количеством лопаток от 2-ух до 4-х штук.

Центробежные насосы обычно устанавливаются выше уровня жидкости в приемном баке, поэтому их перед использованием необходимо наполнить. Наполняют насос при существовании на всасывающей линии обратного клапана сквозь заливную воронку до абсолютного вытеснения газа из всасывающего трубопровода и корпуса насоса. В случае отсутствия обратного клапана, то для наполнения вытесняют воздух из корпуса насоса при запертой задвижке особым вакуумным насосом. Так же делают при наполнении насосов больших габаритов. Центробежные насосы отличаются довольно большим кпд, компактностью и долговечностью использования.

На основе численного моделирования гидродинамических процессов дано обоснование регулировки конструкции рабочих колес центробежных насосов. Проведено математическое моделирование течения жидкости в проточной части центробежного насоса. Анализируются результаты CFD-расчета, после чего создается экспериментальное рабочее колесо и проводятся его испытания. Идет процесс сравнения серийного и опытного насоса.

Ключевые слова: Центробежные насосы, численное моделирование, математическая модель, энергетические характеристики, гидродинамические процессы, динамические характеристики, энергетическое машиностроение, рабочее колесо, рабочая жидкость, лопасти рабочего колеса.

MƏRKƏZDƏNQAÇMA NASOSLARIN ENERGETİK XARAKTERİSTİKALARININ TƏDQİQİ

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XÜLASƏ

Mayenin sorulmasını və basqı altında ötürülməsini təmin edən hidravliki qurğu nasos adlanır. Bir qayda olaraq, oxşar aqreqatlarla mayenin hər hansı bir hərəkətli yerdəyişməsi ona potensial və ya kinetik enerjinin ötürülməsi hesabına həyata keçirilir. Texniki göstəricilərdən asılı olaraq müxtəlif növ nasoslardan istifadə olunur. Eyni zamanda, nasoslar faydalı iş əmsalı, güc, vahid zamanda vurulan maye həcminə,yüksək basqı və və yaranan təzyiqə görə fərqlənirlər.

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Geniş istifadə olunan nasoslar kürəkli nasoslardır. Onların fərqli xüsusiyyəti, tərpənməz gövdə daxilində fırlanma hərəkəti icra edən kürəklərlə təchiz olunan işci carxdır. İşci çarxın konfiqurasiyasından və mayenin işci çarxdan axma şəraitinə görə kürəkli nasoslar mərkəzdənqaçma və qasırğalı növə bölünür.

Mərkəzdənqaçma nasosunda işçi carxın fırlanması zamanı yaranan mərkəzdənqaçma qüvvəsinin təsiri altında maye mərkəzdən carxın kürəkləri boyu ətrafa doğru ötürülür. İşçi carxın kürəkləri fırlanma istiqamətində geriyə doğru əyilmişdir. Kürəklərin sayı, adətən, 6-8 ədəd təşkil edir. Natəmiz mayelərin vurulması üçün olan xüsusi nasoslarda işçi carxda axın kanalının kecidinin artırılması məqsədilə kürəklərin sayı azaldılaraq 2-4 ədəd təşkil edir.

Mərkəzdənqaçma nasosları, adətən, qəbuledici çənnin maye səviyyəsindən yuxarı quraşdırılır, ona görə də istifadə etməzdən əvvəl nasos maye ilə doldurulmalıdır. Məqsəd sorma boru kəmərində olan əks klapan vasitəsilə sorma xəttində və nasosun gövdəsində olan qaz və hava qabarcıqlarının mütləq xaric olunmasını təmin etməkdir. Çekmə klapan olmadıqda, doldurmaq üçün xüsusi vakuum pompası ilə bağlanmış klapan ilə hava nasos korpusundan çıxarılır. Böyük nasosları doldurarkən eyni şey edilir. Mərkəzdənqaçma nasosları yüksək faydalı iş əmsalı, kompakt ölçüləri və uzunmüddətli istismarı ilə xarakterizə olunur.

Hidrodinamik proseslərin ədədi simulyasiyası əsasında mərkəzdənqaçma nasosların işçi çarxlarının konstruksiyasının tənzimlənməsi üçün əsaslar verilmişdir. Mərkəzdənqaçma nasosunun axın hissəsində maye axınının riyazi modelləşdirilməsi aparılmışdır. CFD hesablamasının nəticələri təhlil edilirərək işçi çarxın təcrübi nümunəsi hazırlanaraq sınaqdan keçirilir. Serialı istehsallı nasosun və sınaq nümunəli nasosun müqayisəli təhlili aparılır.

Açar sözlər: Mərkəzdənqaçma nasosları, ədədi simulyasiya, riyazi model, energetik xarakteristikalar, hidrodinamik proseslər, dinamik xarakteristikalar, enerji maşınqayırması, işçi çarx, işçi maye, işçi çarxın kürəkləri.

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IMPROVEMENT OF OPERATING CAPACITY OF OIL PRODUCTION EQUIPMENT CONSIDERING THE INFLUENCE OF DYNAMIC LOADS

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ABSTRACT

In the presented article, the analysis of the effect of the dynamic load falling on the polished rod of the sucker rod pump unit on the normal function of the operating unit during the oil extraction process was carried out. The general formula for the damage caused by the impact of the pump's wellhead packing seal has been derived. The dependence graph of damaged work on the length of the packing seal and the Poisson's ratio of the material was made.

Due to the dynamics of the frictional force generated in the packing seal of the stuffing box appropriately located below the suspension point of the rods, its forced cyclic movement occurs as a result of the impact transmitted to the system which consists of an incompressible fluid column, and the elastic rods. This requires the investigation of the dynamics of the rod pump associated with the probability of unpleasant situations such as the possible resonance occurrence in the specified system, the time between repairs, and the reduction of the working coefficient of the pump, in this regard.

At the same time, the questions such as the coefficient of friction depending on the selection of the material of the packing seal, the reduction of the dynamic accumulation of the load on the system, and the saving of electric energy are also important. It needs to be considered that the operation process is accompanied by a certain energy loss. It should be taken into account that even a small reduction in energy loss can manifest great economic benefits. It should be noted that some issues encountered in the process of operation of oil wells through the rod pump and depending on certain arguments affecting this process were also resolved by those experts.

Keywords: oil production, frictional force, sucker road pump, dynamic load, logging operations, logging cable, separator, energy loss, wellhead packing seal.

Introduction. Nowadays, a significant number of oil wells are operated by the sucker rod pumping method, and the number of wells operated by this method continues to increase. It is of great importance to the process of oil extraction, the analysis of the impact of the dynamic load on the polished rod of the sucker rod pump unit on the normal function of the operating unit. In this direction, A.S. Virnovski showed that there is no method of determining the dynamic load with sufficient results, and the issue of its determination is related to considerable difficulties [1, 2]. In his other work, A.N. Adoni calculated and draw a curve based on the values obtained from his experiment without taking into account the effect of the dynamic friction force at the suspension point and found the maximum load at the suspension point of the polished rod depending on the angular velocity of the crank of pumping unit, but he did not demonstrate the equations describing those curves in his article [1].

A.N. Adonin checked the results obtained according to the theoretical formulas of A.S. Virnovski in the experiments he tried in the experimental well, and confirmed their compatibility with practice. However, neither A.N. Adonin nor A.S. Virnovsky considered the influence of the periodically changing friction force in the wellhead packing seal on the dynamics of the sucker rod pump.

Due to the dynamics of the frictional force generated in the packing seal of the stuffing box appropriately located below the suspension point of the rods, its forced cyclic movement occurs as a result of the impact transmitted to the system which consists of an incompressible fluid column, and the elastic rods (Fig. 1). This requires the investigation of the dynamics of the rod pump associated with the probability of unpleasant situations such as the possible resonance occurrence in the specified system, the time between repairs, and the reduction of the working coefficient of the pump, in this regard.

At the same time, the questions such as the coefficient of friction depending on the selection of the material of the packing seal, the reduction of the dynamic accumulation of the load on the system, and the saving of electric energy are also important. It needs to be considered that the operation process is accompanied by a certain energy loss. It should be taken into account that even a small reduction in energy loss can manifest great economic benefits.

It should be noted that some issues encountered in the process of operation of oil wells through the rod pump and depending on certain arguments affecting this process were also resolved by those experts. One of these arguments - the effect of friction in the well (except for the friction in the packing seal) was taken into account, and the solution to the issues in this direction was reflected in the technical literature. As an example, the rod's own weight, the changing weight of the liquid column, the forces from the inertia of the fluid and the rod's masses, the friction force of the rod against the pipes, as well as the hydrodynamic friction that depends on the displacement speed of the rod, are mentioned as examples of the rod's own weight, and it is shown that as the immersion depth of the pump increases, so does the friction force.

A.N. Adonin in his work takes into account the presence of the tensile force obtained from the compression of the rod on the circumference, but also claims that this force does not affect the suspension point of the rod. It should be noted that neither A.N. Adonin, nor A.S. Virnovsky, who benefited from his experiments, found the maximum load at the suspension point of the rod depending on the angular speed of the crank, but did not take into account the friction force on the packing seal while describing the curves obtained during the pump performance.

It goes without saying, the selection of the operation mode that ensures the reduction of energy loss of the pump and the rational change of the parameters of the pump's sealer in the well is practically important, and in this regard, it is possible that changing the friction coefficient of the sealer material, its physical-mechanical properties and dimensions will affect the energy loss. It is known that geophysical studies are widely used in the drilling and operation of oil and gas wells. The efficient conduct of these studies affects the efficient drilling of wells and the quality of technological processes of oil production.

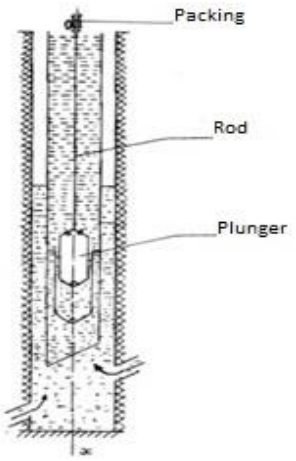

Figure 1: The calculation schematic of the sucker rod pump unit

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The exact depth of the well with geophysical surveys, the direction of the oil flow to the well with the zenith and azimuth angle, the solution of such issues as the sufficiency of the formation pressure, the conditions of the measurement processes depend on the dynamics of the movement of the lifting drum of the draw works, the perforations of the logging probes, torpedoes, and especially the different brands of logging cables. In this case, the most responsible part of the geophysical equipment, the issue of its technical safety, is raised in connection with the dynamics of the movement of the logging cable in the well.

In the investigation of the issue of technical safety related to the movement dynamics of logging cables, the taxonomy of possible threats and the characteristics of the operating conditions should be studied before the research of the wells. [3, 4]

In connection with the above issue, studies have shown that the relationship between the dynamics of logging probes' movement and the strength of the steel wires that make up the armor of the logging cable should be taken into account when it is removed from the well. On the other hand, the reduction of the strength and yield strength of steel wires, and the reduction of the technical safety of the logging cable is due to the effect of the presence of dislocations in the crystalline structure of the wire material on the internal stress; thus, with the creation and propagation of microcracks in the material, the constructive collapse occurs, which causes an increase in the dynamic state of the logging cable and its tension force. [5, 6]

The technical safety of logging cables and the dynamics of the lifting process is also related to the dynamics of the process of removing the logging probe from the well and the variable moment of inertia with respect to the axis of rotation of the lifting drum. [7]

Statics of the logging cable, the rotation movement of the lifting drum, and the effect of the braking moment on its axis on the efficient performance of logging operations should be studied during determining the depth of well with the logging cables the hydrodynamic properties of the drilling fluid in the well, the friction of the logging cable against the lifting drum hook and drilling fluid, the temperature in the well (up to 250°C), linking the movement of the part of the logging cable in the well with the movement of the hollow cylindrical part on the lifting drum with a variable moment of inertia, the effect of the deformation of the logging cable on the accurate measurement of its depth, the technical safety of the logging cable, its static and dynamic the difference of tension forces from the standard breaking force, the deviation of the logging cable from Hooke's law due to the fact that the logging cable has a complex mechanical structure (Fig. 2), the braking moment on the axis of the lifting drum and the possibility of the logging cable twisting due to the retention of the logging probe in the well and wireline truck are the factors that affect the efficient and accurate operation of the machine and should be taken into account due to their complex mechanical structure, the conditions in the well considering the above stated.

In order to carry out the logging operations efficiently and accurately, apart from the braking moment, the lifting drum that makes up the wireline truck, the changing moment of inertia of the logging cable layer, and the movement dynamics of the part of the logging cable in the well should be taken into account. From this point of view, it is necessary to study the impact of the mechanical tools used in the logging operation - the determination of the tension of the logging cable in the equilibrium state in the well, the elements of the wireline truck, and the braking moment in the lifting drum on the dynamics of the logging operation.

Although the sucker rod pump is widely used in the oil production industry, its performance efficiency is not at a sufficient level, and this situation is especially evident in the operation of oil wells with associated gas. Therefore, increasing and improving the efficiency of the pump operation mode is very important as a research issue.

It is important to investigate the dependence between the time t_1 necessary for the gas bubble to travel the length of the working part of the separator and the time t_2 of the pump plunger from the uppermost position to the lowermost position. As a result of this study, it is possible to find the optimal length of the working part of the separator for efficient separation and to improve the separation process.

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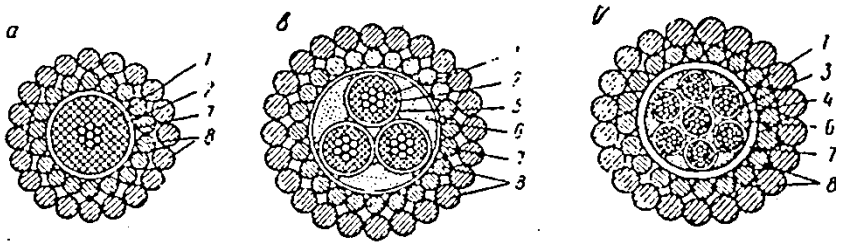

Figure 2: Structure of armored geophysical logging cables
a) single conductor; b) three-conductor; v) seven-conductor; 1) conductor; 2-5- armoring of a conductor; 6- conductive fiber filling; 7- inner armored steel wire; 8- outer armored steel wire.

Considering all the above stated, let's clarify the role of dynamic loads affecting both oil production and geophysical equipment controlling production in terms of improving their performance. First, let's look at the challenge of damage caused by the wellhead packing seal and how it could be reduced.
Choosing the operating mode that ensures the reduction of energy loss of the sucker rod pump and rationally changing the parameters of the wellhead packing seal of the pump are of practical importance. In this regard, it is possible that the physical and mechanical properties of the packing seal material, its friction coefficient, and changing the dimensions will affect the energy loss.
Below, the relationship between the energy loss caused by static and dynamic forces, related to the deformation of the rod and the friction between the packing seal during the working process of the sucker rod pump (Fig. 1), is analyzed, and the general damage is found.
The energy loss obtained under the influence of the wellhead packing seal of the pump is generally expressed by the following formula:

$$A = A_1 + A_2 + A_3 + A_4 + A_5$$

where A_1 is the static load, A_2 is the dynamic, A_3 is the radial stress of the plunger, A_4 is the lost energy received from the friction process of the plunger, and A_5 is the lost energy received from the pressure of the liquid column above the plunger.
Indicated energy losses were calculated and the following formulas have been found by us:

$$A_1 = \frac{\partial U_{rd}}{\partial X}|_{x=0} E f_{rd} l_p$$

where U_{rd} is the static deformation of the rod, E is the Youngs modulus of elasticity, f_{rd} is the cross-sectional area of the rod, l_p is the length of the packing seal.

$$A_2 = \frac{\partial U_{dyn}}{\partial X}|_{x=0} E f_{rd} l_p$$

where U_{dyn} is the dynamic deformation of the rod

$$A_3 = \mu_1 \frac{\mu}{1-\mu} \frac{Q}{f} \pi d_{rd} l_p S_0$$

where μ_1 is the coefficient of friction between the outer surface of the bar and the inner surface of the packing seal, μ is the Poisson's coefficient of the material of the packing seal, Q is the force applied by the worker, d_{rd} is the diameter of the rod, S_0 is the travel of the rod. The cross-sectional area of the rod

$$f = \frac{1}{4}\pi(D^2 - d_{rd})$$

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D - is the diameter of the plunger.

$$A_4 = \frac{2\pi U_e}{1 - cos\omega t}\tau_0 d_{rd} l_p$$

where $U_e = \frac{1}{2}S_0(1 - cos\omega t)$ is the integration equation of motion, t - is the time of the beginning of plunger movement, τ_0 is defined as the frictional stress and is as indicated below:

$$\tau_0 = \mu_1 \frac{\mu}{1 - \mu}\frac{Q}{\mu_{rd}}$$

The last energy loss in the row is determined by the following formula:

$$A_5 = pf l_p$$

where p is the pressure of the liquid column above the plunger.
The static deformation of the rod is expressed by the following formula:

$$U_{rd} = \frac{q(2l_p x - x^2)}{2Ef_{rd}} + \frac{(f_{pl} - f_{rd})P_f l_p g x}{E f_{rd}}$$

where the first term on the right is the static deformation obtained from the rod's own weight and the second term is the static deformation obtained from the weight of the fluid mass of the rod on the plunger, q is the weight of the unit length of the rod, f_{pl} is the cross-sectional area of the plunger, P_f is the density of the liquid, and g is the acceleration of free fall.
Energy loss obtained when dynamic deformation is not taken into account is equal to:

$$A = (f_{pl} - f_{rd})P_f l_p^2 + qll_p + 4\mu_1 \frac{\mu}{1 - \mu}\frac{Qd_{rd}S_0}{D^2 - d_{rd}^2} + \mu_1 \pi \frac{\mu}{1 - \mu}\frac{Qd_{rd}S_0}{f_{rd}} l_p + \frac{1}{4}\pi p(D^2 - d_{rd}^2)l_p$$

Let's keep the pre-defined quantities in the formula of the energy loss - the length of the rod and express the formula with quantities with (l_p), the Poisson's coefficient (μ), which reflects the physical and mechanical properties of its material, and the coefficient of friction between the outer surface of the rod and the inner surface of the packing seal (μ_1) and write the numerical values of the rest of the parameters instead of the energy loss.

Table 1: Pre-defined values of parameters:

diameter of the plunger	$D = 32\ mm$
the radius of the rod	$\tau_{rd} = 10\ mm$
the length of the rod	$l = 1500\ m$
the density of the liquid	$P_f = 1000kq/m^3$
weight per unit length of the rod	$q = 24N/\ m$
the pressure of the liquid column above the plunger	$p = 10\ bar$
manual handling	$Q = 200\ N$
rod travel	$S_0 = 2\ m$
acceleration of free fall	$g = 980\ cm/sec^2$
Youngs modulus of elasticity	$E = 126 \cdot 10^4\ N/mm^2$

The formula of the energy loss develops in the following way after substituting the above numerical values and taking the quantities l_p, μ and μ_1 as arguments;

$$A = 4.8l_p^2 + \left(8.2399 - 8 \cdot 10^6 q\mu_1 \frac{\mu}{1-\mu}\right) l_p, N \cdot m$$

It can be seen from the formula that the energy loss varies according to the law of a square parabola with respect to the length of the packing seal (keeping μ and μ_1 constant). Since the length of the pipe is in meters (the average value is 0.10 m), the first term on the right side of the formula can be ignored, and in this case, the energy loss varies according to the law of a straight line which depends from the length of the pipe l_p. Where μ=0.35, and μ_1=0.25 and the energy loss for (A) is equal to

A=1.076923· 〖10〗 ^5 l_p . According to this formula, the numbers of the energy loss are shown in the table below.

Table 2: Graphs drawn according

l_p, m	0,04	0,08	0,10	0,12	0,14
$A, 10^5 N \cdot m$	0,43076	0,686153	1,07692	1,2930	1,50769

Let's approach the nature of change depending on the parameters of the energy loss by taking the constant length of the packing seal (l_p = 0.1m) and the constant friction coefficient between the outer surface of the rod and the inner surface of the packing seal (μ_1 = 0.25) and Poisson's coefficient μ, which reflects the physical and mechanical properties of the packing seal material. In this case, the energy loss formula (Poisson's coefficient as a reason) is obtained as follows:

$$A = 0.82399 + 2 \cdot 10^5 \frac{\mu}{1-\mu_1}$$

A table built according to this formula:

Table 2: Graphs drawn according

l_p, m	0,25	0,30	0,35	0,40	0,45	0,50
$A, 10^5 N \cdot m$	0,666	0,857	1,077	1,333	1,636	2,000

Graphs drawn according to Tables 1 and 2 are shown in Figure 3.
As can be seen from the graph, the dependence of the energy loss on the length of the packing seal and Poisson's coefficient of the material is linear.

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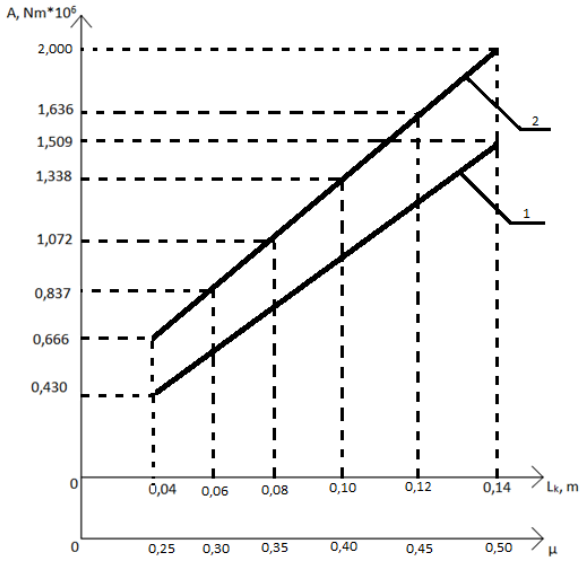

Figure 3: The dependence of the energy loss from the length of the packing seal and the Poisson's coefficient of the material.

Conclusion:

1. The analysis was carried out to identify the influence of the dynamic load on the polished rod of the sucker rod pump on the normal function of the pumping unit in the process of oil production.
2. The general formula has been calculated for the energy loss obtained due to the effect of the wellhead packing seal.
3. The graph was drawn to identify the dependence of the energy loss on the length of the packing seal and the Poisson's coefficient of the material

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DİNAMİK YÜKLƏRİN TƏSİRİNİ NƏZƏRƏ ALMAQLA NEFT ISTISMAR AVADANLIQLARININ İŞ QABILIYYƏTININ TƏKMİLLƏŞDİRİLMƏSİ

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XÜLASƏ

Təqdim olunan məqalədə çubuq nasos qurğusunun cilalanmış gövdəsinə düşən dinamik yükün neft hasilatı prosesində işləyən qurğunun normal işləməsinə təsiri təhlil edilmişdir. Quyu ağzı düyünün gövdəsinin zədələnməsibib uzunluğundan və materialın Poisson əmsalından asılılığının qrafiki tərtib edilmişdir.
Ştokun asma nöqtəsinin altında müvafiq olaraq yerləşən kipləndirmə qutusunda yaradılan sürtünmə qüvvəsinin dinamikası sayəsində, sıxılmayan bir mayenin və elastik ştokun bir sütunundan ibarət bir sistemə ötürülən təsir nəticəsində məcburi tsiklik hərəkət baş verir. Bu, göstərilən sistemdə mümkün rezonans meydana gəlməsi, təmir arasındakı vaxt və bununla əlaqədar nasosun işləmə əmsalı azalması kimi xoşagəlməz halların baş vermə ehtimalı ilə əlaqəli çubuq nasosunun dinamikasının öyrənilməsini tələb edir.
Eyni zamanda, sürtünməyə qarşı contakt materialının seçimindən asılı olaraq sürtünmə əmsalı, sistemdə dinamik yük yığılmasının azaldılması və elektrik enerjisinə qənaət kimi məsələlər də vacibdir. Əməliyyat prosesinin müəyyən enerji itkisi ilə müşayiət olunduğunu nəzərə almaq lazımdır. Nəzərə alınmalıdır ki, enerji itkisindəki kiçik bir azalma belə böyük iqtisadi fayda verə bilər. Qeyd etmək lazımdır ki, neft quyularının bar nasosu ilə istismarı zamanı ortaya çıxan və bu prosesə təsir edən müəyyən arqumentlərdən asılı olan bəzi məsələlər də bu mütəxəssislər tərəfindən həll edilmişdir.
Açar sözlər: neft hasilatı, sürtünmə qüvvəsi, nasos qurğusu, dinamik yük, giriş işləri, giriş kabeli, ayırıcı, enerji itkisi, ağız möhürü.

ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ НЕФТЕПРОМЫСЛОВОГО ОБОРУДОВАНИЯ С УЧЕТОМ ВЛИЯНИЯ ДИНАМИЧЕСКИХ НАГРУЗОК

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РЕЗЮМЕ

В представленной статье проведен анализ влияния динамической нагрузки, приходящейся на полированный шток глубинного насосного агрегата, на нормальную работу рабочего агрегата в процессе добычи нефти. Выведена общая формула для повреждения от воздействия устьевого насоса. Построен график зависимости от длины поврежденного корпуса и коэффициента Пуассона материала.
В представленной статье проведен анализ влияния динамической нагрузки, приходящейся на полированный шток штангового насосного агрегата, на нормальную работу рабочего агрегата в процессе добычи нефти. Выведена общая формула для повреждения от удара сальника устьевого насоса. Построен график зависимости поврежденной работы от длины сальникового уплотнения и коэффициента Пуассона материала.

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За счет динамики силы трения, создаваемой в сальниковом уплотнении сальниковой коробки, целесообразно расположенной ниже точки подвеса штоков, происходит ее вынужденное циклическое перемещение в результате удара, передаваемого на систему, состоящую из столба несжимаемой жидкости, и эластичные стержни. Для этого необходимо исследование динамики штангового насоса, связанное с вероятностью неприятных ситуаций, таких как возможное возникновение резонанса в заданной системе, межремонтная наработка, снижение рабочего коэффициента насоса в связи с этим.
При этом важны и такие вопросы, как зависимость коэффициента трения от выбора материала сальникового уплотнения, снижение динамического накопления нагрузки на систему, экономия электроэнергии. Необходимо учитывать, что рабочий процесс сопровождается определенными потерями энергии. Следует учитывать, что даже небольшое снижение потерь энергии может дать большие экономические выгоды. Следует отметить, что некоторые вопросы, возникающие в процессе эксплуатации нефтяных скважин штанговым насосом и зависящие от определенных аргументов, влияющих на этот процесс, также решались этими специалистами.
Ключевые слова: добыча нефти, сила трения, глубинный насос, динамическая нагрузка, каротаж, геофизический кабель, сепаратор, потери энергии, устье скважины.

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RESEARCH ON THE IMPROVEMENTS OF COUNSTRUCTION OF PUMP JACK WITH ONE-ARM SHOULDER

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ABSTRACT

In the production of oil by downhole rod pumps, as a drive, both in Azerbaijan and abroad, balancing one-arm and two-arm pump jack are most often used ones. In this article the goal is - a comparative study of the advantages of one-arm pump jack over two-arm pump jack. For that, the calculation of the main parameters was maid – displacenemt, speed and acceleration of suspension poin of rods and built comperative graphs for commercially avaible deaxial pump jack type of SKD8-3-4000 and the proposed construction of a one-arm pump jack. There are existing options, for holding a one-arm pump jack on the weight of the balancer when changing the stroke length of the suspension point of the rods that reviewed. Options for improving the one-arm pump jack are proposed.
Keywords: pumping unit, balancer, pump jack, one-arm, two-arm.

Balancing drives of borehole rod pumps - pumping units, can be in two versions: with a two-arm or one-arm balancer. In pumping units with a two-arm balancer, the balancer support is located between the balancer head and the traverse support. In pumping units with a one-arm balancer, the converting articulated four-link mechanism is moved forward, to the well, i.e. traverse support and balancer head are on the same side of the balancer support (pic. 1).

In the middle of the last century, in Azerbaijan, there was an attempt to create a one-arm pump jack with an axial kinematic scheme at the AzINMASH Research and Development Institute of Oil Engineering. This pump jack was designed on the basis of units and parts of axial two-arm pumping units produced in those years. However, this project was not implemented in practice, although the results of theoretical studies showed certain advantages of a one-arm pump jack over existing two-arm axial pumping units.

Among foreign companies producing one-arm pump jacks, one can single out the American company “Lufkin”, the Romanian company “Vulkan” as well as the Russian companies Neftemash, etc. The two-arm pump jacks from “Lufkin” have a small deaxial angle 9º (Fig. 1, a), since the center of rotation of the crank is located on the vertical passing through the point of articulation of the connecting rod with the balance bar in the horizontal position of the balance bar.

As for pump jack with a one-arm balancer, these structures have a deaxial angle of 15° (Fig.1, b). These pump jack in terms of the load on the rods, in terms of torque on the gearbox, in terms of energy and other indicators compare favorably with pump jack with a two-arm balancer.

If in two-arm pump jack the angle of rotation during the up and down stroke was 180°, then in pump jack with a one-arm balancer and a large de-axial, the traverse is shifted relative to the axis of rotation a little closer to the axis of the well, so the upward stroke occurs approximately 195°, and the upward stroke 165°.

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For two-arm pump jack with a small deaxial angle, the speed change coefficient is $K_o \approx 1$. In one-arm pumping units with a large deaxial angle, $K_o = 195/165 = 1{,}18$, i.e. the time to move up is longer than the time to move down. This property is characterized by increased production of high viscosity oil, when the time of oil suction and plunger lift is longer than the pump plunger change time. When moving upwards, at the moment the crank angle of 195^o is reached, acceleration is damped while turning the maximum load into a load on the polished rod.

Installation of a traverse in front provides a valuable mechanical advantage for increased load capacity, and the second most important mechanical advantage is the ability to reduce the load on the downstroke, i.e. the maximum torque in the upper position decreases, and in the lower position it increases [1].

The electric motor must have a power reserve sufficient to overcome the maximum load during the first half of the stroke. It is possible to eliminate such unevenness of the load of the electric motor by appropriate balancing.

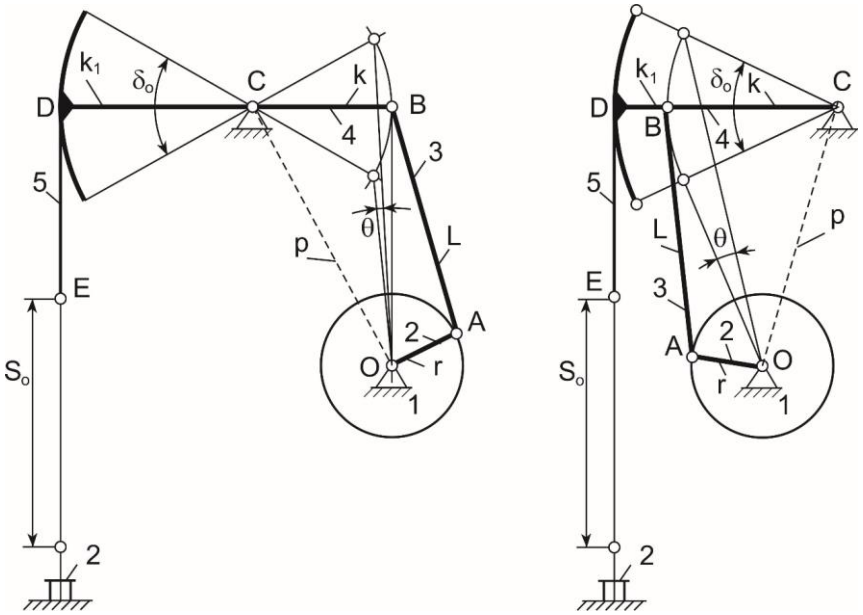

Figure 1: Design schemes of deaxial pump jack: a – two-arm balancer, b – one-arm balancer
1 – driven gear shaft; 2 – crank; 3 – connecting rod; 4 – balancer; 5 – rope; 6 – wellhead

It is known from the theory of operation of the DRPU (downhole rod pumping unit) that the main load on the head of the balancer when it moves up is equal to the weight of the liquid column P_{lc} and rods P_r ($P_{lc} + P_r$). When the head of the balancer goes down, the load becomes equal only to the weight of the rods P_r, since in this case the discharge valve opens and the load from the liquid column is transferred to the pipes. Pump jack with a one-arm balancer are balanced using weights or a pneumatic accumulator. In the first case, the load can be mounted on the balancer, the crank, or on the balancer and the crank at the same time. Balancing is called: balancing, rotary or combined. The most commonly used was the scheme with crank balancing. It is compact, which allows you to design a less metal-intensive drive.

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With crank balancing in two-arm pump jack, balancing weights are located on the axis of the crank. The balancing weights in the one-arm pump jack are displaced from the crank axis. This is because in one-arm pump jack, the traverse does not stand directly above the gearbox, as in two-arm pump jack, but is shifted forward to the balancer head.

This affects the angle of rotation of the crank during the up and down stroke. This is due to the fact that the torque from the counterweights, when started from the top position, "lags" relative to the torque caused by the load in the well by about 8°. Similarly, when starting from the bottom position, the above displacement causes the torque from the counterweights to "lead" the torque from the load in the well by about 8 degrees. Separately, these positions do not create the same moments, but, working together, they create an "equivalent" system, which, when rotated, increases the efficiency of the gearbox by 35%. In addition, in one-arm pump jack, balancing weights are located on the opposite arm of the crank along an axis that is offset relative to the crank axis at a certain angle, which makes it difficult to securely fasten the cranks to the gearbox shaft using a differential tie. In addition, the manufacture of a crank of this shape is also associated with technological difficulties. To improve the design of a one-arm pumping unit, it was proposed to change the design of the crank (Fig. 2).

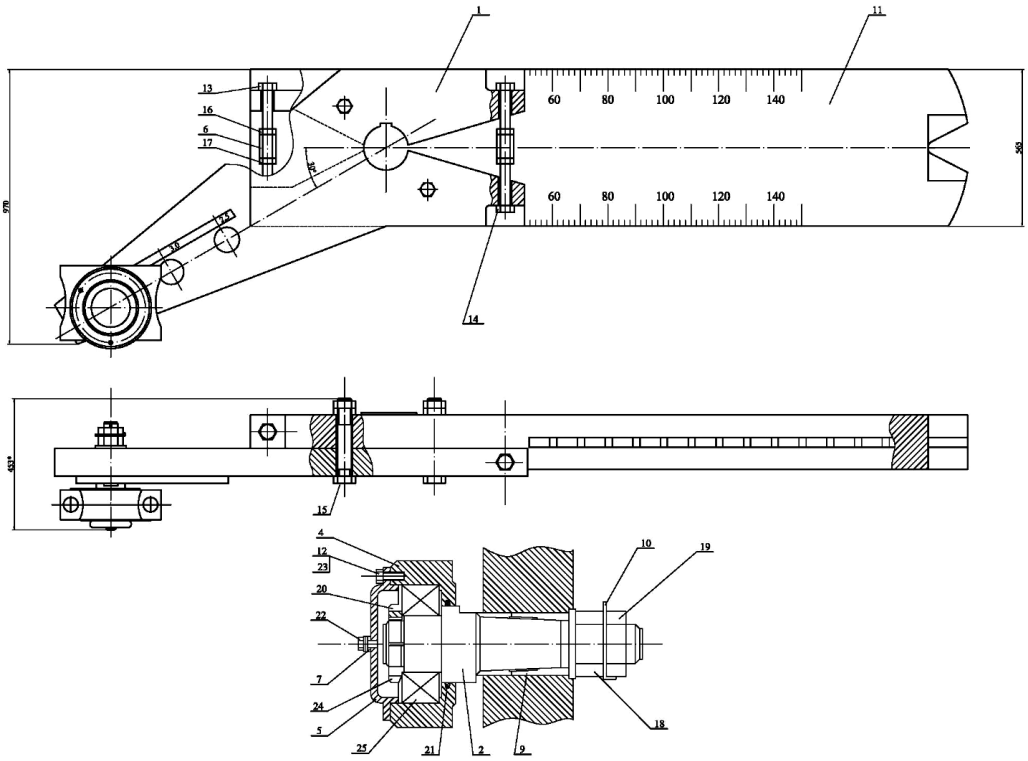

Figure 2: Prefabricated design of the crank of a one-arm pump jack:
1 – front crank; 2 – crank pin; 3 – the lower head of the connecting rod; 4 – gasket; 5 – cover; 6 – coupling nut; 7 – gasket; 8 – washer; 9 – bushing; 10 – washer; 11 – rear crank; 12-15 – bolts; 16-20 – nuts; 21 – ring; 22 – plug; 23, 24 – washers; 25 – bearing

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The main kinematic relations chosen to create a number of standard sizes of the pump jack during its design are the following: r/k; r/l; k_1/k; r/p.
During research on the development of the optimal design of a one-arm pumping unit, computer calculations were carried out and the following kinematic relations were selected:

$$r/k = 0,4; \quad r/l = 0,3; \quad k_1/k = 1,4; \quad r/p = 0,35$$

where r – is the crank radius; k – is the length of the rear arm of the balancer; k_1 – is the length of the front arm of the balance bar; l – is the length of the connecting rod; p – pole distance (distance from the axis of rotation of the driven shaft of the gearbox, to the axis of swing of the balancer).
In addition, when choosing the kinematic relations of a one-arm pump jack, they were also guided by the fact that the junction of the traverse support would be at a sufficient distance from the wellhead, which would make it possible to make the head of the balancer swivel. Study of the main indicators of the selected version of the one-arm pump jack in comparison with the modern two-arm deaxial pump jack of the SKD type, manufactured in accordance with OST 26-16-08-87, displacement (Fig. 3, a), speed (Fig. 3, b) and acceleration (Fig. 3, c) of the rod suspension point (RSP), also shows certain advantages of one-arm pump jacks. Below are the main initial parameters of the studied pumping units: – the maximum stroke length of the rod suspension points for the SKD8-3-4000 pump jack is assumed to be S_o = 3 m, for a one-arm pump jack – S_o = 3,5 m;
- number of swings of the balancer per minute n = 12;
- borehole pump diameter d_p = 38 mm;
- pump descent depth H = 1735m;
- pump rod string – three-stage: Ø19мм – l_1= 49%; Ø22мм – l_2= 27%; Ø25мм – l_3= 24%;
- diameter of tubing d_t = 60mm

Table 1 presents the comparative results of computer calculations of the pumping units selected for the study.

The graphs show that even with a difference in the stroke length of the suspension point of the rods, the performance of a one-arm pump jack is better.
Calculations of the main parameters of a one-arm pump jack were made using a computer program according to the following formulas (Fig.4.) [2]:

-RSP movement from the extreme lower position:

$$S = k_1 (\gamma - \gamma_{min})$$

$$\gamma = \operatorname{arctg}\frac{\sin\varphi}{r/k + \cos\varphi} + \operatorname{arctg}\frac{\sin\beta}{k/l - \cos\varphi}$$

$$\gamma_{min} = \arccos\frac{k^2 + p^2 - (l + r)^2}{2kp}$$

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Table 1: The main parameters of the investigated pump jacks

φ, deg.	Two-arm pump jack			One-arm pump jack		
	S, m	V, m/sec	W, m/sec^2	S, m	V, m/sec	W, m/sec^2
0	0,00	-0,00	3,54	0,00	0,00	1,67
20	0,12	0,83	2,44	0,06	0,45	1,58
40	0,44	1,37	1,46	0,25	0,88	1,48
60	0,86	1,68	0,79	0,55	1,26	1,31
80	1,35	1,82	0,29	0,94	1,59	1,03
100	1,86	1,84	-0,24	1,42	1,83	0,63
120	2,35	1,66	-1,11	1,95	1,93	0,12
140	2,76	1,16	-2,49	2,48	1,93	0,12
160	2,97	0,38	-2,77	2,97	1,61	-1,47
180	2,98	0,38	-1,66	3,35	1,02	-2,82
200	2,86	-0,59	-1,01	3,50	0,01	-4,49
220	2,66	-0,85	-0,87	3,31	-1,39	-5,21
240	2,39	-1,10	-0,97	2,75	-2,59	-2,91
260	2,05	-1,39	-1,17	1,96	-2,88	0,71
280	1,62	-1,73	-1,19	1,22	-2,39	2,41
300	1,10	-1,98	-0,40	0,65	-1,69	2,50
320	0,55	-1,82	1,72	0,28	-1,04	2,15
340	0,14	-1,04	3,64	0,07	-0,49	1,85
360	0,00	-0,00	3,54	0,00	0,00	1,67

-RSP speed:

$$V = -\omega r a_3 \frac{\sin\alpha}{\sin\beta} \qquad \beta = \arccos(A - B\cos\varphi)$$

$$A = \frac{l^2 - p^2 + k^2 - r^2}{2lk}; \qquad B = \frac{p}{l} \cdot a_1;$$

$$\alpha = \arccos(A_1 + B_1\cos\gamma)$$

$$A_1 = \frac{l^2 - p^2 - k^2 + r^2}{2lk}; \qquad B_1 = \frac{p}{a_1 l}.$$

- RSP acceleration:

$$W = -\omega^2 r a_3 \cdot \frac{p}{l} \frac{\cos\alpha \sin\gamma + a_1 \sin\alpha \operatorname{ctg}\beta \sin\varphi}{\sin^2\beta}$$

Here ω – angular velocity of rotation of the crank, ω = πn/30.

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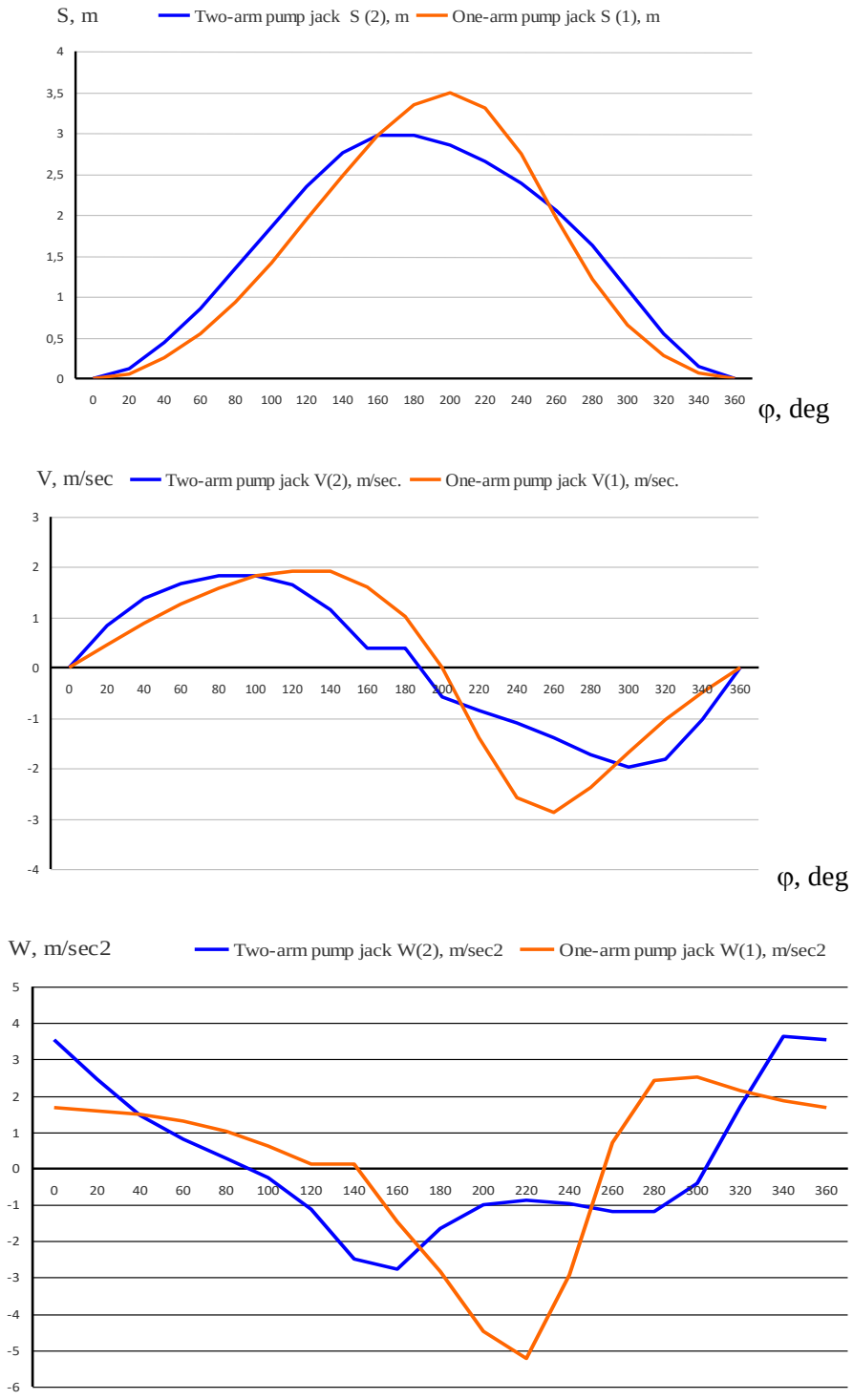

Figure 3: Comparative graphs of movement (a), speed (b) and acceleration (c) of RSP of a two-arm and one-arm pump jack

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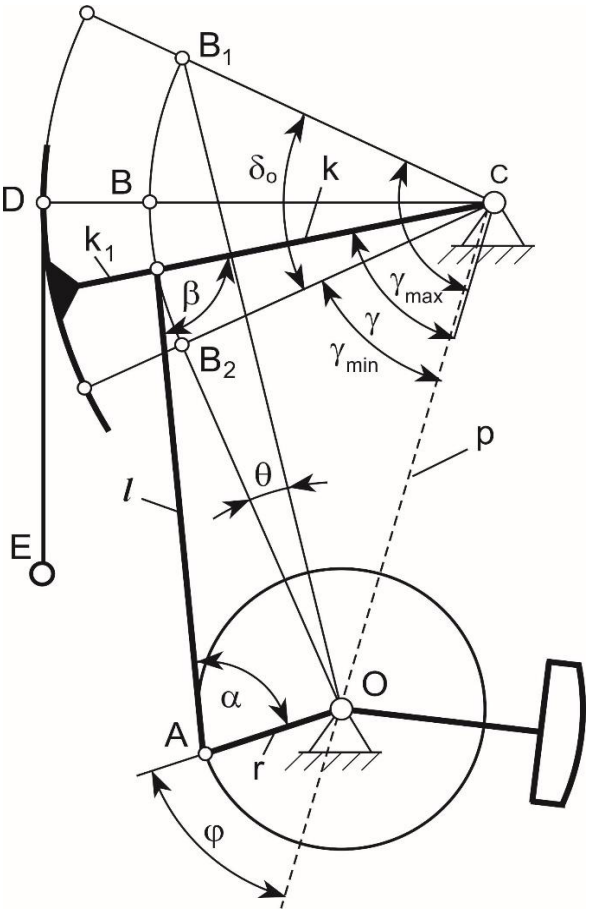

Figure 4: Kinematic diagram of a one-arm pump jack

The dimensions of the links of the converting mechanism of a one-arm balancing pumping unit are determined depending on the maximum stroke length of the RSP, adopted for this design S_o = 3.5 m. The length of the front arm of the balancer is determined by the formula:

$$k_1 = \frac{S_o}{2\arcsin\left\{a_1\sqrt{1+\left[\left(\frac{1}{a_2}\right)^2-1\right]\sin^2\frac{\theta}{2}}\right\}}$$

The deaxial angle θ between the straight lines of the connecting rod in the extreme lower and extreme upper location of point B is determined by this formula:

$$\theta = \arccos\frac{\left(\frac{1}{a_4}\right)^2-\left(\frac{1}{a_1}\right)^2+\left(\frac{1}{a_2}+1\right)^2}{2\frac{1}{a_4}\left(\frac{1}{a_2}+1\right)} - \arccos\frac{\left(\frac{1}{a_4}\right)^2-\left(\frac{1^2}{a_1}\right)^2+\left(\frac{1}{a_2}-1\right)^2}{2\frac{1}{a_4}\left(\frac{1}{a_2}-1\right)}$$

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The value of the rear arm of the balancer k: $k = \frac{k_1}{a_3}$

Crank radius value r: $r = k \cdot a_1$

Connecting lod length value *l*: $l = \frac{r}{a_2}$

The value of the pole distance p: $p = \frac{r}{a_4}$

When $a_1 = \frac{r}{k}$; $a_2 = \frac{r}{l}$; $a_3 = \frac{k_1}{k}$; $a_4 = \frac{r}{p}$.

When changing the operating mode of a one-arm pumping unit, namely, when changing the stroke length, it becomes necessary to disconnect the connecting rods from the cranks, as a result, the balancer becomes unstable due to the lack of a rear arm, which, turning around balancer support, creates problems during repair work.

The elimination of this problem was solved in various ways, for example, with a welded structure of the body of the balancer with the head, the rack was made deflectable with the help of a jack. In another version of the design of a one-arm pumping unit, in order to ensure the stability of the balancer during a change in stroke length, a hinged stand with a handle was provided on the upper shelf of the rack. When this stand was rotated by 90°, it was installed across the balancer, stopping the movement of the balancer under its own weight down during the change in the stroke length of the RSP (Fig. 5). After the repair work is completed, the stand must be returned to its original position in its place. To slow down the possible movement of the cranks during repair work, a two-block brake is installed on the drive shaft of the gearbox.

We propose to eliminate this problem by changing the stroke length of the RSP, namely the radius of rotation of the connection point of the connecting rods with the cranks, without disconnecting the connecting rods from the cranks. To do this, a guide channel is provided on the rear crank 11, along which the lower head of the connecting rod 3 moves by rotating the screw 10. The crank has marks corresponding to the stroke lengths of the RSP, corresponding to standard operating parameters (see Fig. 2).

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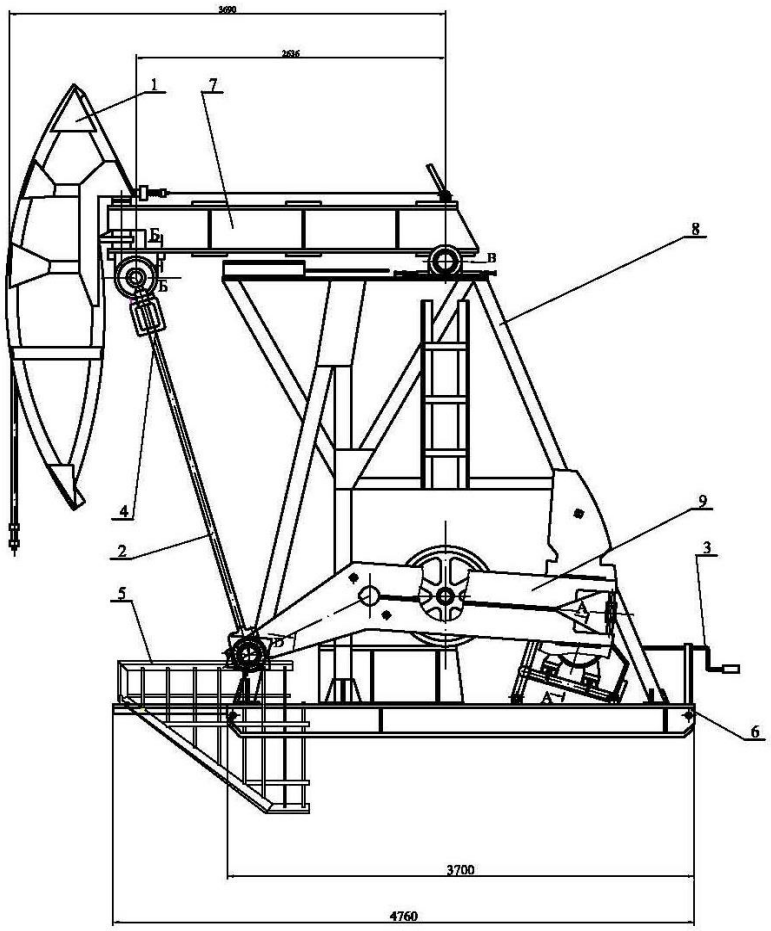

Figure 5: One-arm pump jack: 1 – balancer head; 2 – connecting rod; 3 – brake; 4 – traverse with a support; 5 – fence; 6 – frame; 7 – balancer with support; 8 – rack; 9 – crank with counterweights

Conclusion

In order to improve the design of a one-arm pumping unit, the following proposals were made.

1. As a result of the research, it was proposed to make the design of the crank assembly, consisting of two halves, each of which is installed on the driven shaft of the gearbox with a key and fixed with a differential tie.
2. When changing the stroke length on the crank, provide for a smooth movement of the lower head of the connecting rod along the axis of the crank with a screw.

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ИССЛЕДОВАНИЯ ПО СОВЕРШЕНСТВОВАНИЮ КОНСТРУКЦИИ ОДНОПЛЕЧИХ СТАНКОВ-КАЧАЛОК

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РЕЗЮМЕ

При добыче нефти скважинными штанговыми насосными установками в качестве привода, как в Азербайджане, так и за рубежом чаще всего используются балансирные двуплечие и одноплечие станки-качалки. В данной статье поставлена цель сравнительного исследования преимуществ одноплечих станков-качалок перед двуплечими станками-качалками. Для этого был проведен расчет основных параметров – перемещения, скорости и ускорения точки подвеса штанг и построены сравнительные графики для серийно выпускаемого дезаксиального станка-качалки типа СКД8-3-4000 и предлагаемой конструкции одноплечего станка-качалки. Рассмотрены существующие варианты удержания на весу балансира одноплечего станка-качалки при изменении длины хода точки подвеса штанг. Предложены варианты совершенствования одноплечего станка-качалки.
Ключевые слова: скважинные штанговые насосные установки, балансир, станок-качалка, одноплечий, двуплечий.

TƏKQOLLU MANCANAQ DƏZGAHLARININ KONSTRUKSİYASININ TƏKMİNLƏŞDİRİLMƏSİNİN TƏDQİQİ

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XÜLASƏ

Həm Azərbaycanda, həm də xaricdə quyu ştanqlı nasos qurğuları ilə neft hasilatında ən çox ötürücü kimi tarazlı iki qollu və bir qollu mancanaq dəzgahlardan istifadə olunur. Bu məqalədə bir qollu mancanaq dəzgahların iki qollu mancanaq dəzgahlara nisbətən üstünlüklərinin müqayisəli tədqiqi məqsədi qoyulur. Bunun üçün əsas parametrlərin hesablanması aparıldı - SKD8-3-4000 tipli mövcud olan deaksial mancanaq dəzgahı və təklif olunan bir qollu mancanaq dəzgahının konstruksiyası üçün ştanqların asma nöqtəsinin yerdəyişməsi, sürəti və təcili hesablandı və müqayisəli qrafiklər quruldu. Ştanqların asma nöqtəsinin gediş yolu uzunluğunu dəyişdirərkən bir

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qollu mancanaq dəzgahının tarazın çəkisini saxlanması üçün mövcud variantlar nəzərdən keçirilir. Bir qollu mancanaq dəzgahının təkmilləşdirilməsi variantları təklif olunur.
Açar sözlər: quyu ştanqlı nasos qurğuları, taraz, mancanaq dəzgahı, bir qollu, iki qollu.

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METHODS FOR ASSESSING THE TECHNICAL CONDITION OF DRILL ROTORS

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ABSTRACT

This article, devoted to methods for assessing the technical condition of drill rotors, will help to consider the problem of servicing industrial equipment. The relevance of this work lies in the fact that in today's time, with the development of industrial sectors, both in our country and in other countries, there is a need for new and effective approaches to assessing the technical condition of equipment. Especially with the expansion of the boundaries of the oil and gas industry, the number of unexplored deposits is increasing. To process such deposits, there is a need to introduce new methods of maintenance. In order to increase the productivity of equipment that works for a long time, sometimes continuously, it is important to adhere to certain service methods. The aim of the work is to study the available methods for assessing the technical condition of drill rotors and propose a new integrated approach that combines the available indicators and criteria of known methods. This article discusses in detail the methods for assessing the technical condition of drill rotors, their characteristics are studied. The objectives of this work are to analyze the available methods for assessing the technical condition of drilling equipment, to determine the procedure for establishing the noise and vibration characteristics of rotors, to develop criteria for assessing the technical condition of the rotor. The article also analyzes the factors affecting the operation of drill rotors in operating conditions. Having studied the existing methods, a new integrated method is proposed, which, through a point approach and the choice of a specific method, based on the available data on the unit, will ensure higher reliability and longevity of the drill rotors used. The use of an integrated method is based on the calculation of all important points that are relevant to the object under study. The proposed method will have to reduce errors and malfunctions of drill rotors, increase the accuracy and service life of the equipment. The choice of an integrated method will help to ensure the continuous operation of drill rotors in industrial enterprises.
Keywords: drilling rotor, method, control, damage, wear, factors, detection, vibration monitoring, noise characteristics, evaluation.

Relevance of the work

At the current stage of technological progress, special attention is paid to the diagnostics of units and equipment, forecasting the residual resource and assessing the technical condition. During drilling wells, the most time-consuming unit for assessing the technical condition is the drill rotor. In the course of work, in the process of drilling, skills and especially forecasting the condition of the equipment is a factor that helps to protect the drill rotor, as well as other units from any complications, to more fully exploit the resource of the downhole engine and bit. This on the state of the rotor is necessary, since accidents occurring due to a malfunction of the rock-

destroying tool are among the most difficult. As a result, assessing the technical condition of the drill rotor and forecasting the time of its operation to failure serves as an urgent task, the solution of which can be achieved by increasing the reliability of the well wiring process, reducing accidents and improving the technical and economic indicators of drilling.

Purpose of the study

The purpose of the study is to consider the available methods for assessing the technical condition of drill rotors and propose a new integrated approach that combines the available indicators and criteria of known methods.

Objectives of the study:

1. Analysis of existing methods for assessing the technical condition of drilling equipment.
2. Determination of the procedure for establishing the noise characteristics of rotors and methods of their measurement.
3. Determination of the procedure for establishing the vibration characteristics of rotors and methods of their measurement.
4. Development of criteria for assessing the technical condition of the rotor.
5. Proposing a new integrated approach based on known methods.

Results of the study.

In the standards and specifications for the rotors of drilling rigs, the values of the noise and vibration characteristics entered in the passports of the rotors of drilling rigs shall be established.

The noise characteristics of the rotors are received by sound power (dB) levels in octave bands with average geometric frequencies of 63, 126, 250, 500, 1000, 2000, 4000 and 8000 HZ. For the compilation of noise characteristics, the values of samples of the selected rotors are considered, where the values of the average sound values are not higher than the corresponding levels with minimum sound values of more than 4 dB. The values of the spectral components of the noise shall not exceed the minimum levels in the respective bands by more than 5 dB. The main characteristics of the rotor are: maximum speed, number and shape of the gear teeth, weight, overall dimensions, etc. The main mode of operation of the rotor is the rotational speed and load, which meets the noise characteristic.

The determination of the noise characteristic of the rotor shall be made by measuring noise at a distance of 1 m from the outer contour of the rotor under conditions of a free sound field. Noise measurement shall be made at least at 8 points on the measuring surface. If the level difference at adjacent points exceeds 5 dB, measurements shall be made at additional points located between the received measuring points. At each measuring point, at least three measurements of sound levels shall be made with the probe characteristic (dBA) enabled, as well as the sound pressure levels in each of the octave bands (dB).

The vibration characteristic of the rotors shall establish the effective (RMS) values of the oscillatory velocity (m/s) or their levels (dB) in octave bands with mean geometric frequencies of 2;4;8;16;31.5; 63; 125; 250 Hz. In order to assess the quality of procurement and repair of rotors, the current value of vibration displacement (mm) in the frequency range of 1.5-355 Hz should be indicated in the technical documentation for rotors. The vibration characteristic of the rotors shall be established in the form of numerical values of vibration velocities and vibration displacement. Vibration is measured in m/s at the effective value of the vibration velocity or in decibels (dB) at the level of vibration velocity in the frequency range from 1.4 to 366 Hz.

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Vibration measurements are made on the rotor housing in a direction perpendicular to the support surface. Determination of the spectral composition of vibration and vibration displacement values is made at the point with the highest total level of vibration among the points. The vibration interference level on the table of the Doge's rotor test shall be at least 10 dB lower than the vibration level occurring during rotor operation in all octave frequency bands. It is allowed to carry out vibration measurements on stands where the level of interference in the octave bands is 4-9 dB lower than the level measured by the operation of the rotor.

A method for assessing the technical condition of a drill rotor by vibromonitoring. High efficiency of vibration monitoring can be achieved by periodically collecting vibration data for all measuring points, through the fulfillment of the requirements and recommendations given in the equipment documentation. Assessment of the vibration state of drilling equipment is carried out based on the results of the data of the general level of vibration velocity (can be calculated by spectrum), taking into account the values of the threshold levels of the "Warning" and "Accident" states.

Method of assessing the quality control of installation and repair of the drill rotor. For the initial assessment of the quality of installation and repair of different units of the same type and size, the intensity of vibrations (RMS value) measured in a large frequency range - from 10 Hz to 1000 Hz is used.

Evaluation method through operational detection of depressurization of the drill rotor body. To control the leakage violation, it is proposed to use the method of direct narrowband spectrum - the vibration acceleration spectrum, measured in a wide frequency range - from 10 Hz to 10000 Hz. In this case, after the initial analysis, a frequency range is established that has information about the state of the sealing units and lubrication contamination. After that, the power of oscillations in this spectral range of high frequencies is measured. The moment of depressurization is determined by increasing the speed changes in the power of oscillations in a certain high-frequency region. This method allows you to increase the resource of drilling equipment by at least 2-3 times, to ensure its reliability and trouble-free operation.

Methods of assessing the technical condition by the method of non-destructive testing and their classification. The main methods of evaluation in general industrial practice are: magnetic-powder, radiation, ultrasonic, visual, eddy current, acoustic-emission, capillary, magneto-ferrometric.

In order to control the condition of the drilling rotor, three methods of non-destructive testing have become widespread: ultrasonic, capillary and magnetic-powder. When drilling wells under production conditions, the following types of assessment are taken into account:

- wear control by external diameter;
- control of the thickness of the walls of the equipment and column parts;
- detection of fatigue damage at the ends of the steel parts of the rotor;
- control of the wall thickness of the internal thread of the rotor support.
- identification of material wear;

Method of complex assessment of the vibration state of the drill rotor. During vibration monitoring of the state of drill rotors, there are basically two problems. First, it is necessary to use a large amount of measurement information, and secondly, it is necessary to periodically compare the state of the equipment under changing operating conditions. Errors in the manufacture of parts of drilling machines, defects in components, defects in assembly and installation, wear of

triboconjuressions are manifested in the vibration signal in various ways, so the received diagnostic signal must be differentiated in accordance with the types of defects detected. To monitor changes in the technical condition of drilling machines, it is important to determine a generalized vibration diagnostic feature that allows detecting and separating in the initial stage of development various types of defects that affect the resource.

A comprehensive method for assessing the technical condition of drill rotors. We propose a new integrated assessment method that is based on the above methods. That is, in addition to the partial method of integrated assessment of the vibration state of the drill rotor, it is necessary to make an overall assessment taking into account the available data. The structural diagram of the proposed method is shown in Figure 1.

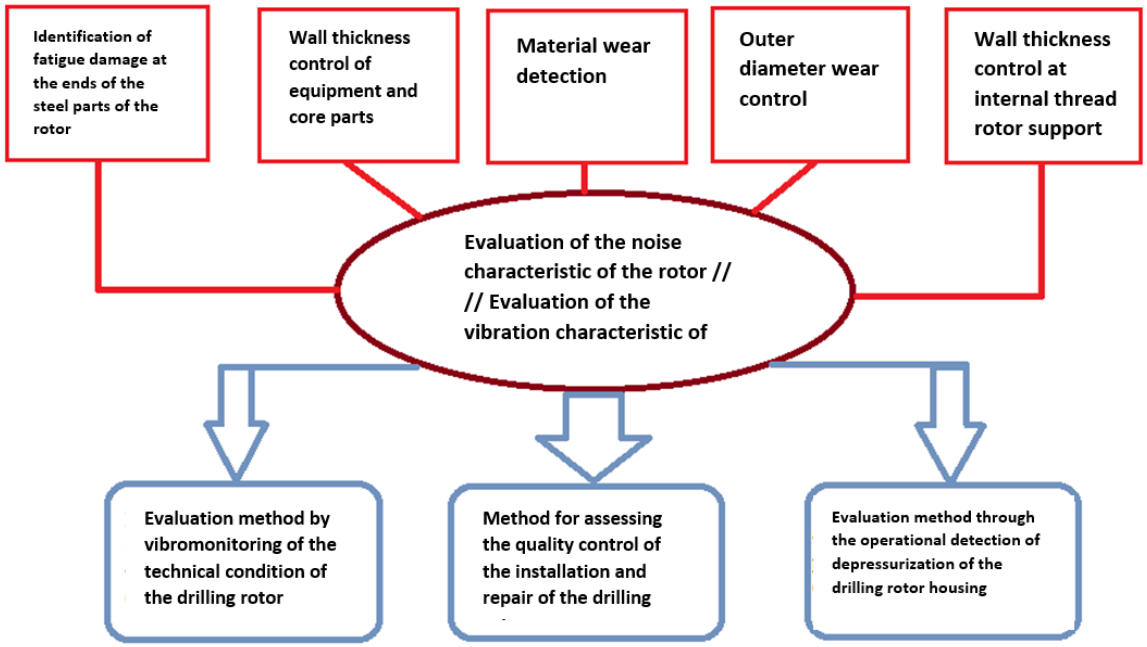

Figure 1: Structural diagram of an integrated method for assessing the technical condition of drilling rotors.

The essence of the method lies in the fact that taking into account the data on wear by external diameter, the thickness of the walls of the equipment and column parts, fatigue damage at the ends of the steel parts of the rotor, the wall thickness of the internal thread of the rotor support and the wear of the material, we assess either the noise and vibration characteristics of the rotor. Then, from the data obtained, we come to the final method, that is, we choose one of the methods for assessing the technical condition of the drill rotor.

Findings

This integrated approach contributes to a more accurate assessment of the technical condition of drilling equipment. Since the available methods are focused in one direction, and when introducing an integrated method, all the important points that are relevant to the object under study will be taken into account. The proposed method will help reduce errors and malfunctions of drill rotors, increase their accuracy and service life.

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МЕТОДЫ ОЦЕНКИ ТЕХНИЧЕСКОГО СОСТОЯНИЯ БУРИЛЬНЫХ РОТОРОВ

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РЕЗЮМЕ

Данная статья, посвященная методам оценки технического состояния бурильных роторов, поможет рассмотреть проблему обслуживания промышленных оборудований. Актуальность данной работы состоит в том, что в сегодняшнее время, при развитии промышленных отраслей, как в нашей, так и в других странах, появляется надобность к новым и эффективным подходам оценки технического состояния оборудования. Особенно при расширении границ нефтегазовой отрасли, увеличивается число неизученных залежей. Для обработки таких залежей есть необходимость внедрения новых способов технического обслуживания. В целях повышения продуктивности техники, которая долго, иногда непрерывно работает важно придерживаться определенным методам обслуживания. Целью работы является изучение имеющихся методов оценки технического состояния бурильных роторов и предложение нового комплексного подхода, который объединяет в себе имеющиеся показатели и критерии известных способов. В этой статье подробно рассмотрены методы оценки технического состояния бурильных роторов, изучены их характеристики. Задачами данной работы являются анализ имеющихся методов оценки технического состояния бурильного оборудования, определение порядка установления шумовых и вибрационных характеристик роторов, выработка критериев оценки технического состояния ротора. Также в статье проанализированы факторы, влияющие на работу бурильных роторов в эксплуатационных условиях. Изучив существующие методы, предложен новый комплексный метод, который путем точечного подхода и выбора

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конкретного метода, основывающиеся на имеющиеся данные об агрегате обеспечит более высокую надежность и долголетие используемых бурильных роторов. Использование комплексного метода основывается на расчете всех важных моментов, которые имеют отношение к исследуемому объекту. Предлагаемый метод должен будет снизить ошибки и неполадки бурильных роторов, увеличить точность работы и срок службы оборудования. Выбор комплексного метода, поможет обеспечить непрерывную работу бурильных роторов в промышленных предприятий.
Ключевые слова: бурильных ротор, метод, контроль, повреждение, износ, факторы, выявление, вибромониторинг, шумовые характеристики, оценка.

QAZMA ROTORLARININ TEXNİKİ VƏZİYYƏTİNİN QİYMƏTLƏNMƏSİ ÜSULLARI

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XÜLASƏ

Qazma rotorlarının texniki vəziyyətini qiymətləndirmə metodlarına həsr olunmuş bu məqalə sənaye avadanlıqlarına xidmət problemini nəzərdən keçirməyə kömək edəcəkdir. Bu işin aktuallığı ondan ibarətdir ki, bu gün həm bizim, həm də digər ölkələrdə sənaye sahələrinin inkişafı ilə avadanlıqların texniki vəziyyətini qiymətləndirmək üçün yeni və səmərəli yanaşmalara ehtiyac var. Xüsusilə neft və qaz sənayesinin sərhədləri genişləndikdə araşdırılmamış yataqların sayı artır. Bu cür yataqların işlənməsi üçün yeni təmir metodlarının tətbiqinə ehtiyac var. Uzun müddət, bəzən fasiləsiz işləyən bir texnikanın məhsuldarlığını artırmaq üçün müəyyən texniki xidmət metodlarına riayət etmək vacibdir. İşin məqsədi qazma rotorlarının texniki vəziyyətini qiymətləndirmək üçün mövcud metodları öyrənmək və mövcud göstəriciləri və məlum metodların meyarlarını birləşdirən yeni inteqrasiya olunmuş bir yanaşma təklif etməkdir. Bu məqalədə qazma rotorlarının texniki vəziyyətinin qiymətləndirilməsi üsulları ətraflı müzakirə olunur, xüsusiyyətləri öyrənilir. Bu işin vəzifələri qazma avadanlığının texniki vəziyyətini qiymətləndirmək üçün mövcud metodların təhlili, rotorların küy və vibrasiya xüsusiyyətlərinin qurulması qaydasını müəyyənləşdirmək və rotorun texniki vəziyyətini qiymətləndirmək üçün meyarların hazırlanmasıdır. Məqalədə istismar şəraitində qazma rotorlarının işinə təsir edən amillər də təhlil edilmişdir. Mövcud metodları araşdıraraq, avadanlıq haqqında mövcud məlumatlara əsaslanaraq dəqiq yanaşma və müəyyən bir metod seçməklə istifadə olunan qazma rotorlarının daha yüksək etibarlılığını və uzunömürlülüyünü təmin edəcək yeni bir kompleks metod təklif edildi. Kompleks metodun istifadəsi tədqiq olunan obyektlə əlaqəli bütün vacib məqamların hesablanmasına əsaslanır. Təklif olunan metod qazma rotorlarının səhvlərini və nasazlıqlarını azaltmalı, avadanlıqların düzgünlüyünü və xidmət müddətini artırmalıdır. Kompleks metodun seçilməsi sənaye müəssisələrində qazma rotorlarının fasiləsiz işləməsini təmin etməyə kömək edəcəkdir.
Açar sözlər: qazma rotoru, üsul, nəzarət, zədələnmə, aşınma, amillər, aşkarlama, vibrasiya monitorinqi, küyün xüsusiyyətləri, qiymətləndirmə.

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PROSPECTIVE PHYSICO-CHEMICAL METHODS OF INCREASING THE RECOVERY (EOR) FOR OIL FIELDS WITH THE CATEGORY OF HARD-TO-EXTRACT OILS

Introduction.

Increased oil production by water injection, which is widely used in the use of oil fields, is well-known for its high results in the early stages of operation in low-cost oil reservoirs. Because of the masses of this method, only cold water was hit by the layers **Malik Abdullayev[1], Samira Mansurova[2], Nicat Qazanfarli[3]**
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ABSTRACT

It is known that many technologies to improve the oil recovery factor in fields at a late stage of development are being used. However, there are no universal technologies that ensure the effective displacement of residual oil in the reservoir by changing the filtration and volumetric parameters of rocks and the rheological properties of fluids depending on the geological characteristics of the reservoirs. In the article, based on the analysis of well-known works carried out on the selection of the appropriate oil for displacement oil in the reservoir, taking into account changes in some reservoir parameters, research work was conductedwith the purpose to prepare a new composition.

The question of searching for a composition capable of maintaining oil-displacing properties at different temperatures in reservoir conditions, not changing its viscosity at large temperature differences, and also capable of retaining the properties of removing oil particles absorbed there from the surface in contact with the reservoir is relevant. the surface of the rock was examined by laboratory studies. The viscosities of the found composition at various temperatures were determined using a viscometer, and the optimal composition with a stable viscosity was determined by replacing the components with numerous laboratory experiments. Under laboratory conditions, the process of displacement of oil under various compositions with a slug of the composition at different temperatures was carried out.

The results obtained are satisfactory, and the effective behavior of the composition at bed temperatures of 30-80 ^{0}C has been experimentally confirmed.

If we take into account that the compositions injected into the reservoir undergo certain changes under the influence of reservoir temperature and pressure, then certain changes in its properties will inevitably occur when the composition comes into contact with reservoir fluids. Therefore, the ability of the prepared composition to form a precipitate or gel upon contact with various formation waters was also studied.

The results of laboratory studies of physical and chemical technologies for enhanced oil recovery in fields treated by water injection and thermochemical treatment are presented. These technologies can be used in reservoirs with hard-to-recover reserves of high-viscosity oil.

Keywords: viscosity, residual reserve, bed, surfactant, gel, oil displacer.

, increasing the oil spill, but it also had negative consequences. Cold water has caused a sharp decline in layer temperatures, resulting in a steady increase in residual oil in the layers. On the other hand, it was impossible to extract these reserves, in traditional ways. Therefore, many scientific research has been undertaken to solve this artificial problem. /1, 2, etc./. It should be noted that such difficult oil reserves are also evident in oil deposits that are naturally used in extreme climates. Many heating methods, including heat-steam, cycle-steam, and their combinations, are used in the development of deposits under these conditions. The results of laboratory and mine tests of physicochemical technologies for increasing oil yield in oil fields under the heat-steam influence are known. In these studies, a promising concept was developed using formation energy or the energy of a heat carrier injected into the formation to create oil-displacing fluids, gels, and sols. The physicochemical basis for EOR was developed using the following chemical intelligent systems: based on surfactant (SAS), the self-regulating complex features, which can optimally squeeze oil in the formation for a long time, are developed. Mining tests of EOR technologies by using flotation systems and surfactant (SAS) compositions have been successfully carried out in oil fields of many countries. Such systems are systematically produced in Russia and China. The results of pilot tests and the consequences of commercial application are investigated.

Currently, the main oil fields of Azerbaijan (as well as the oil fields of Russia and other CIS countries) are being exploited at the final stage of development, where the current degree of water cut is more than 80%. Residual oil in watered-out formations constitutes a significant part of reserves. Part of hard-to-extract oil reserves in Azerbaijan (as well as in Russia) is constantly increasing. In this case, due to the increase in oil production, the potential growth of oil reserves is of particular importance. According to experts' estimates, the world's hard-to-extract oil reserves are more than 1 trillion tons. It is important to create and widely apply EOR technologies for their effective development [4, 6, 9]. There is a need for science-based technologies to improve oil production adapted to difficult conditions and to develop new chemical reagents for the application of these technologies. It is promising to develop the concept of "smart" oil-displacing and gel-forming compositions, such as physicochemical systems with self-regulating negative feedback, which keep the complex colloidal-chemical properties optimal for oil compression and containment in the reservoir for a long time.

Methodological part.

It is known that laboratory studies and mining tests of new physicochemical EOR technologies involving thermotropic gel-forming and oil-displacing systems aimed at complex conditions are being carried out [4, 6, 9]. Gels redistribute the percolation of fluid streams in the formation and improve compatibility during liquefaction or heat-steam injection. Oil-squeezing systems have low interfacial tension at the oil-oil interface, reducing shale swelling and allowing residual oil to be displaced from both high and low-permeability formation zones. For this purpose, a system consisting of surface-active agent - urea - ammonium salt - water is injected as spirits before injecting the heat carrier. Due to the high temperature of the heat carrier in the formation, urea undergoes hydrolysis, and carbon dioxide and ammonia are obtained. Unlike ammonia, carbon dioxide is more soluble in oil than in water. It is known that the distribution coefficient of CO_2 in the oil-water system varies from 4 to 10 at 35 – 100 ^oC and 10 ÷ 40 MPa pressure, and it does not exceed $6 \cdot 10^{-4}$ for ammonia. Therefore, in the oil-water system, the oil phase will be enriched with CO_2 and the water phase will be enriched with ammonia, in this phase together with the

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ammonium salt, it forms an alkaline system with a maximum buffer capacity of pH 9 ÷ 10 [5, 11, 15], which is necessary for the displacement of oil that is considered optimal. In this case, a few beneficial effects are also observed: - CO_2 solution dissolved in oil reduces its viscosity; - the presence of CO_2 and ammonia in the heat carrier phase facilitates the maintenance of the vapor-gas mixture at a temperature below the vapor condensation temperature, thereby increasing the efficiency of the migration of oil components through the distillation mechanism. In addition, CO_2 and ammonia reduce the swelling of clay minerals in reservoir rocks, thereby maintaining the initial permeability of the formations. The ammonia buffer system formed when ammonia is dissolved in an aqueous solution of an ammonium salt performs the same function. Increases reverse rock wetting and additional oil displacement due to alkalinity, pH = 9-10, and the presence of surfactants. Ammonia buffer system reduces the interfacial tension and helps to detach and thin the high-viscosity layers or films from the surface that form at oil-water-rock boundaries, which weaken fluid percolation and hinder oil extraction [5, 8, 10].

The experience of applying EOR technologies in Russian oil fields showed that the technologies that increase compatibility with the injected liquid (water, steam, gas, etc.) or simultaneously increase both the compatibility and compression factors of oil are considered the most promising. In-form generation of gels is one of the promising methods used to improve compatibility by water injection and thermal steam action.

Various methods are known for obtaining gels, which differ according to the type of gelling reaction. Hydrolytic polycondensations are the most common reactions that give inorganic coagulation gels or condensation-crystallization structures, for example, gels of metal hydroxides and silicic acid [9, 11]. Reactions of the formation of three-dimensional polymer structures as a result of cross-linking of macromolecules of natural and synthetic polymers by chemical or coordination bonds (polyacrylamide cross-linked with chromium salts, polysaccharides cross-linked with borates, etc.) [5], as well as phase transitions in solution - gel systems: polymer with a higher or lower critical temperature - water (cellulose ethers, polyvinyl alcohol, etc.) [3, 10].

Considering these data, the formation of thermotropic inorganic and polymer gel forming systems that form gels in the formation in laboratory conditions to investigate water injection or thermochemical compatibility was investigated. Each oil field has its own geological and physical characteristics. Oil composition and formation rock composition, oil viscosity, water salinity, formation temperature, and pressure vary over wide ranges. Therefore, it is necessary to develop gel-forming systems with tunable properties to utilize gel technologies designed to enhance oil recovery. For this purpose, the study of physicochemical and hydrodynamic aspects of the formation of gels from different aqueous solutions in the formation is continued. Aqueous solutions are low-viscosity solutions under surface conditions, and they gel under formation conditions. The arrival occurs as a result of the thermal energy of the formation or the injected heat carrier, as well as the interaction of the injected solution with formation fluids and collector rocks. The kinetics of gel formation, as well as the rheological and filtration properties of different types of gels, are studied for inhomogeneous layers with conductivity from 0.01 to 10 mkm^2. Thermotropic gel-forming systems with different gelation times - from several minutes to several days - are studied in the temperature range of 30 - 100 ^0C. Based on these systems, various gel technologies have been developed to increase the recovery of residual oil from highly heterogeneous formations, and laboratory experiments are being conducted in their reservoir model.

Results and discussion.

Laboratory-developed and thermotropic inorganic gels for oil recovery the ability of aluminum salt - urea - water - surfactant system to form an inorganic gel and CO_2 in the reservoir is designed to increase compatibility during injection of water or heat transfer agents in the temperature range of 30 - 100 °C is the basis of technology. The possibility of forming free or connected dispersed systems (sols and gels) in the layer was studied, based on the principle of "formed reagents (homogeneous precipitation)", which is well known in analytical chemistry in particular, by the method of condensation. Within the framework of this principle, the innovation implemented at the expense of the thermal energy of the layer or the energy of the injected heat carrier has been proposed as a physicochemical method to increase the rate of oil extraction. Its mechanism of action is explained as follows: a homogeneous aqueous solution consisting of the proposed prepared gel-forming system is injected into the layers. One of the components of the formation system (urea) is gradually hydrolyzed due to the thermal energy of the formation or the energy of the injected heat carrier. The resulting hydrolysates change the pyrolytic equilibrium of other components, causing hydrolytic polycondensation of monomer units by a cooperative phenomenon mechanism. Sometimes a gel is formed almost immediately in the entire volume of the solution. While developing a physicochemical method for increasing oil production, based on the ability of the aluminum salt-urea-water-surfactant system to form inorganic gel and CO_2 under formation conditions, the principle of "formed reagents (homogeneous precipitation)" was implemented. Gel-forming liquids based on this system are low-viscosity solutions with a pH of 2.5-3.5. They are able to dissolve the carbonate minerals of the formation rock and reduce (minimize) clay swelling. Solutions were prepared using saline. They are pumped into formations through injection wells using standard equipment. In the collector, urea is hydrolyzed to form ammonium and carbon dioxide due to its own thermal energy or the energy of the injected heat carrier, causing a gradual increase in the pH of the solution. When the pH value reaches 3.8-4.2, aluminum ions are hydrolyzed, and as a result, in a certain period, an aluminum hydroxide gel is immediately formed in the practical volume of the entire solution. Gel formation time depends on the temperature of the formation and the ratio of the components in the gel-forming system. Due to the gelation of the layer, the water permeability of the rock decreases by 4-35 times. The higher the initial water saturation and rock-reservoir permeability, the greater the degree of permeability reduction. The static shear stress of the gel varies from 3 to 40 Pa. The presence of surfactants in the gel-forming solution intensifies the wetting of the reservoir rocks, thereby improving the solution's ability to penetrate and displace oil. In addition, surfactants have a plasticizing effect on aluminum hydroxide gel and can foam carbon dioxide and ammonium formed in the urea hydrolysis process.

Conclusion.

The rheological properties of the gel correspond to the thixotropic pseudo-plastic body of the coagulation structure. A distinctive feature of the gel is its permeability to the aqueous phase at shear stresses lower than the static shear stress of the gel itself. Gel formation causes the reorganization of leachate flows, equalizes the intake profile of injection wells, and reduces the dilution of well production.

At 70–100 °C, the kinetics of gel formation is determined by urea hydrolysis, which is slower than the aluminum hydroxide gel formation process, which is carried out as a cooperative event. The effect of temperature on the time of gel formation is subject to the Van't-Hoff rule for

chemical reactions: with every 10 degrees increase in temperature, the time until gelation increases by 3.5 times.

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ÇƏTİN ÇIXARILA BİLƏN NEFTLƏR KATEQORİYASINA MALİK NEFT YATAQLARI ÜÇÜN PERSPEKTİVLİ FİZİKİ-KİMYƏVİ NEFTVERİMİNİN ARTIRILMASI ÜSULLARI (NAÜ) TEXNOLOGİYALARI

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XÜLASƏ

Məlumdur ki, neft yataqlarının işlənməsində geniş tətbiq olunan suvurma yolu ilə neft hasilatının artırılması aşağı özlülüklü neft yataqlarının işlənməsinin ilkin mərhələsində yüksək nəticələr əldə etməyə imkan verir. Bu üsulun geniş tətbiqi sayəsində laylara yalnız soyuq suyun vurulması neft hasilatını artırsa da, o, həm də mənfi nəticələrə gətirib çıxarır. Belə ki, laylara soyuq suyun vurulması, lay temperaturunun kəskin aşağı düşməsinə səbəb olub ki, bu da laylarda qalan neftin özlülüyünün yüksəlməsinə, layda onun hərəkətinin pisləşməsinə, beləliklə qalıq ehtiyatların daim artmasına səbəb olub. Bu qalıq ehtiyatlar çətin çıxarıla bilən ehtiyatlar kateqoriyasına keçir ki, onların ənənəvi üsullarla çıxarılması qeyri mümkün olur. Bu problemin həlli üçün isə əlavə xərclərin çəkilməsinə, yeni innovativ texnologiyaların işlənib hazırlanmasına ehtiyac duyulur. Bu səbəbdən də məqalədə su vurma və termokimyəvi təsirlə işlənmiş yataqlarda neftveriminin yüksəldilməsi üçün fiziki-kimyəvi texnologiyaların laboratoriya tədqiqatlarının nəticələri təqdim olunur. Bu texnologiyalardan çətin çıxarılabilən ehtiyatlara malik olan yataqlarda istifadə oluna bilər. NAÜ-nün fiziki və kimyəvi əsasları, kimyəvi sistemlərdən istifadə etməklə hazırlanmışdır: uzun müddət layda neftin sıxışdırılması üçün optimal olan, özünü tənzimləmə xassələrinə malik, səthi aktiv maddələr əsasında gel əmələ gətirən və neftsıxışdırıcı sistemlər hazırlanmışdır. Yüksək özlülüklü neft yataqları da daxil olmaqla, çətin çıxarılabilən ehtiyatları olan yataqlar üçün neftvermənin artırılması və quyuya suyun təcridi texnologiyaları işlənib hazırlanmışdır. Çətin çıxarılan neft ehtiyatlarının səmərəli işlənməsi və neft hasilatının daha da artırılması üçün layların təsirlə əhatə dairəsini artıran fiziki-kimyəvi üsullarla birgə, su və ya istilik daşıyıcılarının vurulması yolu ilə layın təsir əhatəsini və neftin sıxışdırılma əmsalını artırmaqla işlənmənin intensivləşdirilməsi üçün təkmilləşdirilmiş texnologiyalar təklif edilir.
Açar sözlər: texnologiya, gel, özünütənzimləmə, ehtiyat, neftverimi.

ПЕРСПЕКТИВНЫЕ ФИЗИКО-ХИМИЧЕСКИХЕ ТЕХНОЛОГИИ МЕТОДОВ УВЕЛИЧЕНИЯ НЕФТЕОТДАЧИ (МУН) НА НЕФТЯНЫХ МЕСТОРОЖДЕНИЯХ С КАТЕГОРИЯМИ ТРУДНОИЗВЛЕКАЕМЫХ НЕФТЕЙ

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РЕЗЮМЕ

Известно, что увеличение добычи нефти за счет заводения пластов, широко применяемого при разработке нефтяных месторождений, позволяет добиться высоких результатов на начальном этапе разработки месторождений маловязких нефтей. Из-за широкого применения этого метода закачка в пласты только холодной воды хоть и увеличивает добычу нефти, но приводит и к отрицательным результатам. Таким образом, закачка в пласты холодной воды вызвала резкое падение температуры пласта, что привело к

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увеличению вязкости оставшейся в пластах нефти, ухудшению ее движения в пласте, в результате чего, постоянное увеличение в остаточных нефтяных запасов. Эти остаточные запасы нефтей, относятся к трудноизвлекаемым запасам, которые не могут быть извлечены традиционными методами. Для решения этой проблемы необходимо нести дополнительные затраты и разрабатывать новые инновационные технологии. По этой причине в статье представлены результаты лабораторных исследований физико-химических технологий увеличения дебита нефти на месторождениях, обработанных закачкой воды и термохимическим воздействием. Эти технологии могут быть использованы на месторождениях с трудноизвлекаемыми запасами. Физико-химическая основа МУН разработана с использованием химических систем: разработаны гелеобразующие и нефтевытесняюшие системы на основе ПАВ с саморегулирующимися свойствами, оптимальные для длительного вытесния нефти в пласте. Для месторождений с трудноизвлекаемыми запасами, в том числе месторождений высоковязкой нефти, разработаны технологии повышения нефтеотдачи и изоляции притока воды на скважину. Для эффективной разработки трудноизвлекаемых запасов нефтей и дальнейшего увеличения добычи нефти, наряду с физико-химическими методами которые увеличивают охвата воздействия пластов, предложены усовершенствованные технологии интенсификации разработки за счет увеличения охвата воздействием пласта и увеличением степени вытеснения нефти при закачкой воды или теплоносителей.
Ключевые слова: технология, гель, саморегуляция, запас, нефтеотдача.

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VOLUMETRIC RIGIDITY OF HYDRAULIC SYSTEMS

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ABSTRACT

A hydraulic drive is a set of interacting hydraulic devices that is designed to be ghosted by means of a working fluid under pressure. The main element in hydraulic drives most machines is a power hydraulic cylinder. Hydraulic cylinder refers to volumetric hydraulic devices, since their operating mode is to fill the volume of the working chamber and empty it. The very principle of operation of the hydraulic cylinder is based on the movement of the worker organ (piston, membrane, plunger), under the influence of the energy of the flow fluid or the mechanical energy of external forces (gravity, spring). Depending on the principle of operation of hydraulic cylinders, it can be divided into two groups: one-way hydraulic cylinder, two-acting hydraulic cylinders. To ensure the operation of the hydraulic cylinder, a pump is required, the purpose of which is to convert mechanical energy into the energy of the flow fluid. Studying the stiffness of a hydraulic cylinder can help determine the optimal load that a hydraulic cylinder can withstand, as well as help in choosing the right size of hydraulic cylinder for a particular system. The stiffness of the hydraulic cylinder can be determined by measuring the movement of the hydraulic cylinder as the load increases in a given range. For example, a hydraulic press can be used to increase the load on a hydraulic cylinder to a certain value, and then a measuring tool can be used to determine the movement of the hydraulic cylinder. This data can be recorded on a computer, which can then be used to analyze and calculate the stiffness of the hydraulic cylinder. The stiffness of the hydraulic cylinder can be expressed in newtons per millimeter or other units depending on the specific measurement system. By using various materials (indicated in the literature), the results of studies aimed at determining the reduced volumetric stiffness of high-pressure hoses and the dependence of the reduced volumetric stiffness of the hydraulic cylinder on the change in the volumes of the working cavities in the process of moving its rod are given.
Keywords: hydraulic system, volumetric stiffness, hydraulic cylinder, module, hydromechanical systems, hoses, pressure, rod, dynamics.

The purpose of the work: to study the stiffness of the hydraulic cylinder and as a result of the study to show the dependence of rigidity on the modulus of elasticity, the amount of work and operating conditions.

Problem statement. The significant development of electronic devices for calculating mathematical problems has led to an increase in the popularity of numerical methods for calculating differential equations that describe the operation of hydromechanical systems (HMS) under non-stationary conditions. One of these methods uses the concept of "reduced volumetric stiffness" (RVS), which is the necessary pressure increment, to change the volume of the considered area of the hydraulic system per unit.

To calculate the POJ of various hydraulic devices, including hydrolines, a number of formalized dependencies were obtained. However, in this work, due to the lack of necessary devices, there is

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no confirmation at the experimental level of the obtained analytical formulas. However, formulas for calculating the hydraulic line housing can only be used for shells with mechanical properties the same in all directions, made of materials whose modulus of elasticity is much higher than the modulus of elasticity of the working fluid. At the same time, high-pressure hoses (RVD) are widely used in the power hydraulic drive, the elastic properties of which are still not subject to strict analytical characterization. In this case, the RVS (reduced volumetric stiffness) should be determined experimentally.

In connection with the above, the following tasks were set in this work:

- to develop a methodology and conduct virtual experimental studies, as a result of which the obtained analytically obtained formulas for calculating the RVS of the piston hydraulic cylinder (HC) would be confirmed or refuted;
- to develop a methodology and conduct virtual experimental studies that are aimed at determining the RVD RVS.

RVS piston hydraulic cylinder. It should be noted that by changing the internal volumes of the working cavities of the HC in the process of use, as a result, their RVS (reduced volumetric stiffness) also change. This change is shown by the following formulas:

$$C_{pr.p} = \frac{E_l}{\pi d^2 x\left(1+\frac{d}{\delta}\frac{E_l}{E_w}\right)+4V_{p.t}}; \quad (1)$$

$$C_{пр.шт} = \frac{4E_l}{\pi(L-x)\cdot\left[(d^2-d_{pc}^2)+\frac{d^3}{\delta}\frac{E_l}{E_w}\right]+4V_{pc.t}}, \quad (2)$$

where $S_{pr.p}$ and $S_{p.pc}$ are the RVS of the piston and rod cavities of the HC respectively; L – full stroke of the rod; d_{pc} – rod diameter; d – inner diameter of the HZ sleeve in a non-stressed state; x – movement of the rod; E_l and E_w – modulus of elasticity of liquid and wall material HC, respectively; δ is the wall thickness of the HC; $V_{p.t}$ and $V_{pc.t}$ - the volume of harmful space of the piston and rod cavities of the HC, respectively.

In order to substantiate the above analytical dependencies, virtual-experimental studies of a hydraulic cylinder with a piston diameter d_p = 80 mm, a rod diameter d_{pc} = 40 mm, a rod stroke length of L = 0.9 m, a sleeve wall thickness of 10 mm were carried out.

Methods of research of the hydraulic cylinder. The determination of the RVS HC (the given volumetric rigid hydraulic cylinder) was carried out on a special stand, the scheme of which is shown in Fig. 1.

To measure the controlled values, the following devices were used: to determine the stroke value of the hydraulic cylinder rod - a metal ruler with a measurement limit of 1000 mm and a division price of 1 mm; for pressure control – model manometers with a measurement limit of 25 MPa, a division price of 0.1 MPa and an accuracy class of 0.4; to determine the movement of the rod as a result of deformation of the hydraulic cylinder body and the compressibility of the working fluid under the influence of pressure changes - an electronic caliper with a division price of 0.01 mm.

Before the start of the series of experiments, the stand was carefully prepared. The tested hydraulic cylinder and all other elements of the hydraulic system were filled with working fluid in such a way as to guarantee the absence of free volumes of air and other gas inclusions in the internal cavity. Absolute tightness of the system is ensured. Throughout the experiment, the hydraulic pump H remained on.

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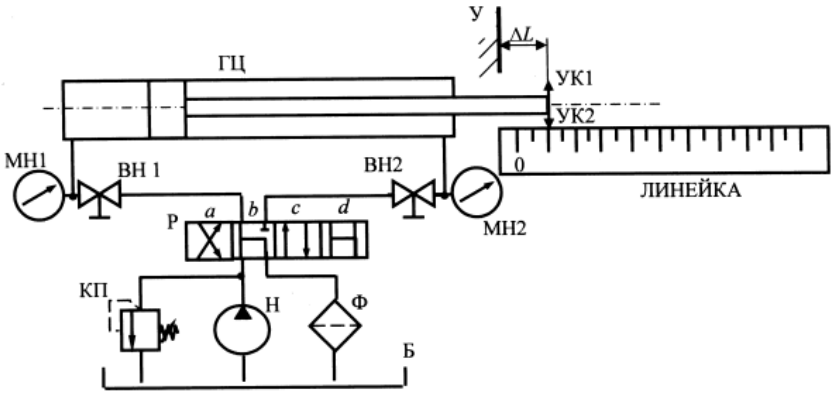

Figure 1: Schematic diagram of the stand for determining the RVS of the working cavities of the piston HC

The experiments were carried out as follows. The HC rod is completely retracted inside the sleeve. Indicators UK1 and UK2, fixed on the HC rod, are combined with the 0 ruler and with the mobile support U, located on the fixed frame of the stand, respectively. The stand is ready to go.
With the BN2 valve closed and the BH1 valve open, the hydraulic distributor P is installed in position "c", the working fluid from the hydraulic pump H moves into the piston cavity of the hydraulic cylinder HZ. Due to the compression of the working fluid, which is located in the rod cavity of the HC, and the deformation of its wall, the rod is extended, while the pressure in both the piston and rod cavities increases. The pressure level is controlled by MN1 and MN2 manometers. After the cp safety valve is activated, the BH1 valve is hermetically closed, and the spool of the hydraulic distributor P is transferred to the position "d", which ensures the unloading of the hydraulic pump H.
The full stroke of the rod is controlled by the ruler. With the help of a caliper, the movement of the rod ΔLi1 is controlled, which occurred as a result of the total deformation of the working fluid, which is located in the rod cavity of the HC and its wall - the distance from the Y stop to the UK1 pointer.
Then the VN2 valve opens. The working fluid flows out of the rod cavity of the hydraulic cylinder into the hydraulic tank B, and the rod is extended by an amount of ΔLi2 due to the expansion of the working fluid in the piston cavity and compression of its previously deformed wall. It should be noted here that the distance between the stop Y and the pointer UK1 is the total movement of the rod

$$\sum \Delta Li = \Delta Li1 + \Delta Li2 \quad (3)$$

where i is the permutation number of the stop Y (in the described case i = 1), i = 1 ... n.
Moreover, n depends on the measurement limit of the caliper and the total stroke of the HZ rod. The measurements described above are made as long as the caliper provides the measurement of ∑ΔLi.
Then the emphasis Y is rearranged (i = 2). The stroke of the rod is fixed along the ruler, at which the rearrangement of the stop U. The experiment continues until the rod of the hydraulic cylinder is completely extended from the sleeve. Processing of experimental data was carried out as

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follows (Fig.2). At each position of the HC rod, starting from 0, the following calculations are made:

- the change in the volumes of the rod ΔVsti and piston ΔVni cavities of the hydraulic cylinder is determined:

$$\Delta V_{штi} = \frac{\pi(d_p^2 - d_{pc}^2)}{4} \Delta L_{i1}, \quad ; \ (4)\Delta V_{пi} = \frac{\pi d_p^2}{4} \Delta L_{i2}$$

- for this position of the rod of the hydraulic cylinder, the given volumetric stiffnesses of its cavities are determined:

$$C_{pc} = \frac{P_{pc}}{\Delta V_{pci}}, \quad ;(5)\ C_{pc} = \frac{P_{pc}}{\Delta V_{pci}}$$

- the given modulus of elasticity for each of the cavities of the hydraulic cylinder is calculated:

$$E_{pc} = C_{pc} \frac{\pi d_p^2}{4} L, \quad E_p = C_{pc} \frac{\pi(d_p^2 - d_{pc}^2)}{4} L \qquad (6)$$

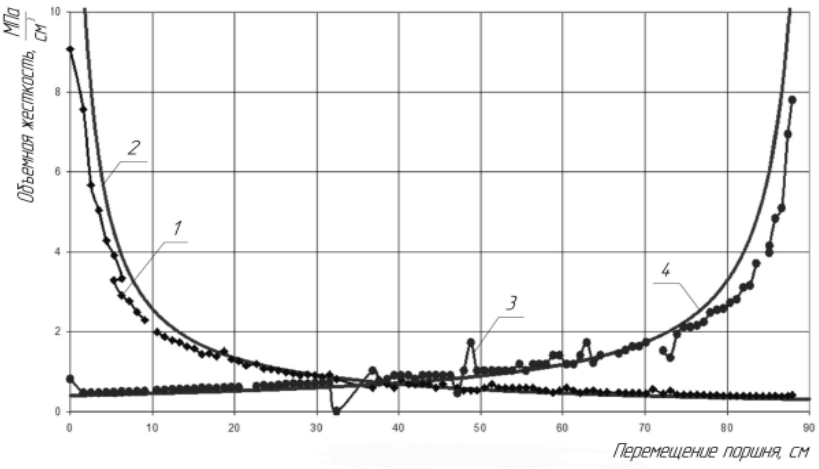

Figure 2: Graphs of changes in the RVS of the cavities of the piston HC when moving its rod: 1 - the piston cavity is experimental; 2 – theoretical piston cavity; 3 – experimental rod cavity; 4 – theoretical stem cavity

Calculations were made along the entire course of the rod of the hydraulic cylinder, which is L = (0... 90) see para.

The results of virtual-experimental studies of the hydraulic cylinder, given in the form of graphs 1 and 3 in Fig. 2, prove that the nature of the dependencies of the RVS of the working cavities of the piston hydraulic cylinder on the movement of its rod, obtained experimentally and calculated according to the above formulas, is identical. The error between the calculated and experimental values of the RVS is not more than 10-15%, which with this error makes it possible to use the proposed formulas to describe the dynamic processes occurring in the working cavities of the hydraulic cylinders.

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Reduced volumetric stiffness of RVD. The experimental determination of the RVD RVS was carried out according to a specially developed technique using a stand made on the basis of the MP-600 cargo piston manometer (Fig. 3).

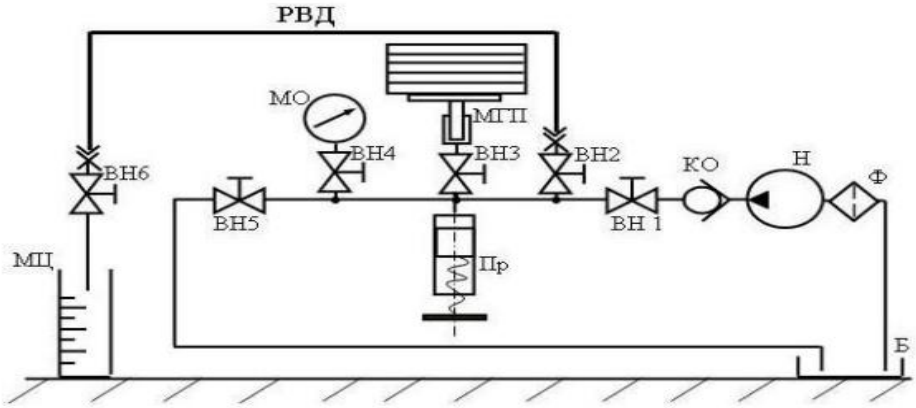

Figure 3: Hydraulic scheme of the stand for determining the RVD PAW

Work on the stand was carried out in the following order. With a manual hydraulic pump H, the working fluid is taken from the hydraulic tank B and through the check valve KO and the open valve BH1 is pumped into the internal cavity of the stand. Valves VN5 and VN6 are hermetically sealed, and valves VH2, VN3 and VN4 are open. When the pressure inside the hydraulic system of the stand is reached, controlled by the sample (MO) and load-piston (IHP) manometers of the required level, the BH1 valve is closed. After that, with the help of a screw press Pr, the pressure is smoothly brought to the required value. The BH2 valve is closed, which isolates the internal volume of the tested RVD from the volume of the hydraulic system of the stand. The VN6 valve opens, and as a result of compression of the deformed RVD, the volume of liquid is displaced from it into the corresponding measuring cylinder, due to the injection of which the pressure inside the sleeve was increased.

In order to improve the accuracy of measurements, several measurements (from 3 to 15) were carried out at each pressure.

Experimental data was processed using the following dependencies:

$$V = \frac{V_{\Sigma}}{N}; \qquad C_{пр} = \frac{P}{v} \tag{7}$$

Where is

V is the average volume of the liquid displaced from the RVD during one cycle of its loading at each pressure level;

V∑ is the total volume of the liquid displaced from the RVD for all experience at a given pressure level; N is the number of loading cycles at a given pressure level;

SPR – RVS RVD at pressure p.

The results of RVD studies are given in the form of graphs in Fig.4-6, which depict the experimentally obtained dependencies of the RVD POJ on pressure.

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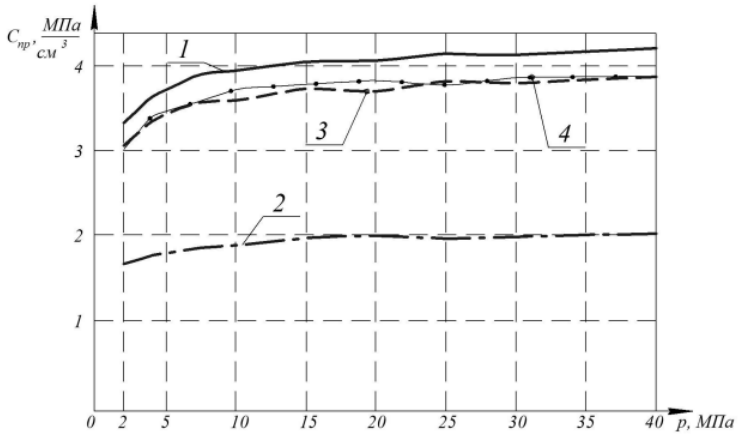

Figure 4: Graphs of dependence on the pressure of the RVD RVS with a nominal pass diameter d1 = 16 mm, the length of which, without taking into account the length of the nozzles (net length, rubber cord shell), is L11 = 0.94 m (1); the same hose length L12 = 1.94 m (2); the same sleeves, recalculated by 1 linear meter of their length (3) and (4) respectively.

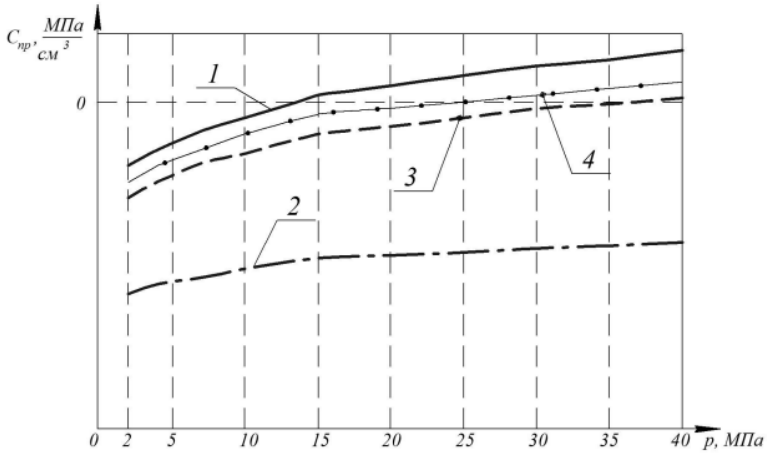

Figure 5: Graphs of dependence on the pressure of the RVD WITH the diameter of the nominal passage d2 = 32 mm, length L21 = 0.88 m (1); the same hose length L22 = 1.88 m (2); the same sleeves, recalculated by 1 linear meter of their length (3) and (4) respectively.

Analyzing the obtained curves, it is easy to notice that the reduced volumetric stiffness of all studied RVDs at a low loading level (p < 15 MPa) increases nonlinearly with increasing pressure. This nature of the change in the RVS of rubber-cord RVD can be explained by the fact that in the specified zone of pressure change, a change in their internal volume occurs as a result of sampling the gaps between the strings of the braided metal cord. With a further increase in pressure inside the shell, its RVS changes linearly, since in this case there is a stretching of the strings that form the cord. That is, here the shell with some approximation can be considered as a metal surface with certain stiffness characteristics.

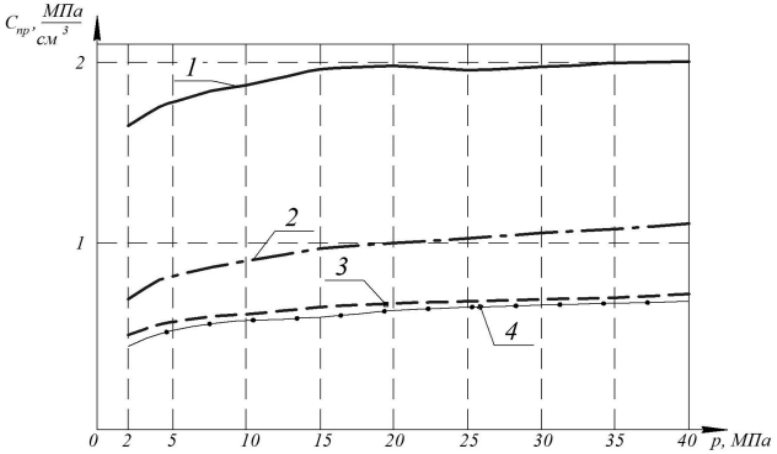

Figure 6: Graphs of the dependence of the RVD POJ: the diameter of the conditional passage d1 = 16 mm, the length L12 = 1.94 m (1); nominal diameter d2 = 32 mm, length L21 = 0.88 m (2); of the same hoses included in the chain in parallel, obtained experimentally (3) and calculated analytically using experimental data (see Figure 3, Curves 1 and 2) (4).

Conclusion. According to the above results obtained during virtual-experimental studies, the following conclusions can be obtained:

1. As previously mentioned, the formulas proposed in (1) for the determination of the PWP coincide with the experimental data with high and necessary accuracy, and as a result can be used to describe the dynamics of the processes that occur in hydraulic drives;
2. When describing the dynamic processes occurring in RVD, experimental dependencies of their RVS on the force acting on the area (pressure) can be used. It is also obvious that when determining the RVS RVD of different lengths, there is no need for experimental studies of each of them, it is enough to know the RVS lengths of shells of various types, as a result of which it will be possible to calculate the reduced volumetric stiffness of high-pressure hoses for any length made of these shells.

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ОБЪЁМНАЯ ЖЁСТКОСТЬ ГИДРАВЛИЧЕСКИХ СИСТЕМ

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РЕЗЮМЕ

Гидропривод – это совокупность взаимодействующих гидравлических устройств, который предназначен для привидения в действие механизмов и машин посредством рабочей жидкости под давлением. Основным элементом в гидроприводах большинство машин является силовой гидроцилиндр. Гидроцилиндр относятся к объёмным гидравлическим устройствам, так как их рабочий режим заключается в заполнение объёма рабочей камеры и её опустошении. Сам принцип действия работы гидроцилиндра основан на перемещение рабочего органа (поршня, мембраны, плунжера), под воздействием энергии жидкости потока или механической энергии внешних усилий (силы тяжести, пружина). В зависимости от принципа действия гидроцилиндров можно разделить на две группы: гидроцилиндр одностороннего действия, гидроцилиндры двустороннего действия. Для обеспечения работы гидроцилиндра требуется насоса, цель которого заключается в преобразование механической энергии в энергию жидкости потока. Исследование жёсткости гидроцилиндра может помочь определить оптимальную нагрузку, которую гидроцилиндр может выдержать, а также помочь в выборе правильного размера гидроцилиндра для конкретной системы. Жёсткость гидроцилиндра может быть определена путём измерения перемещения гидроцилиндра при нарастании нагрузки в заданном диапазоне. Например, гидравлический пресс может быть использован для наращивания нагрузки на гидроцилиндр до определенного значения, а затем измерительный инструмент может быть использован для определения перемещения гидроцилиндра. Эти данные могут быть записаны на компьютере, который затем может использоваться для анализа и вычисления жёсткости гидроцилиндра. Жёсткость гидроцилиндра может быть выражена в нютонах на миллиметр или других единицах в зависимости от конкретной системы измерения. Путём использования различных материалов (указаны в литературе) приведены результаты исследований, направленных на определение приведенной объёмной жёсткости рукавов высокого давления и зависимости приведенной объёмной жёсткости гидравлического цилиндра от изменения объёмов рабочих полостей в процессе перемещения его штока.
Ключевые слова: гидросистема, гидропривод, объёмная жёсткость, гидроцилиндр, модуль, трубопровод, насос, гидромеханические системы, давление, шток, динамика.

HİDRAVLİK SİSTEMLƏRİN HƏCM SƏRTLİYİ

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XÜLASƏ

Hidravlik muhərrik - təzyiq altında işçi maye axını vasitəsilə maşın və mexanizmləri hərəkətə gətirmək üçün qarşılıqlı əlaqədə olan hidravlik qurğuların toplusudur. Hidravlik intiqalların əsas elementi, əksər maşınlarda, güc silindri hesab olunur. Hidravlik silindr həcmli hidravlik intiqallara

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aiddir, çünki onların iş rejimi işçi kameraların həcmini maye ilə doldurmaq və boşaltmaqdır. Hidravlik silindrin işləmə prinsipi axın mayesinin enerjisinin və ya xarici qüvvələrin mexaniki enerjisinin (cazibə qüvvəsi, yay) təsiri altında işçi orqanın (porşen, membran, plunjer) yerdəyişməsinə əsaslanır. Hidravlik silindrləri təsir prinsipindən asılı olaraq iki qrupa bölmək olar: birtəsirli hidravlik silindr və ikitəsirli hidravlik silindrlər. Hidravlik silindrin işləməsini təmin etmək üçün nasos tələb olunur ki, onun da məqsədi mexaniki enerjini maye axının enerjisinə çevirməkdir. Hidravlik silindrin sərtliyinin tədqiqatı, hidravlik silindrin dözə biləcəyi optimal yükü müəyyənləşdirməyə və eyni zamanda konkret bir sistem üçün hidravlik silindr düzgün ölçüsünü seçməyə kömək edə bilər. Hidravlik silindrin sərtliyi, verilən diapazonda yüklənmənin artdığı halda hidravlik silindrin hərəkət yerdəyişməsini ölçməklə müəyyən etmək olar. Məsələn, hidravlik press, hidravlik silindrdəki yükü müəyyən bir qiymətə qaldırmaq üçün istifadə edilə bilər və daha sonra isə hidravlik silindrin hərəkət yerdəyişməsini təyin etmək üçün bir ölçmə vasitəsi istifadə edilə bilər. Hidravlik silindrin sərtliyini təhlil etmək və hesablamaq məqsədilə, bu məlumatlar kompüter yaddaşına yazılmaqla istifadə edilə bilər. Hidravlik silindrin sərtliyi, konkret ölçmə sistemindən asılı olaraq millimetrə olan nyutonlarda və ya digər vahidlərdə ifadə edilə bilər. Müxtəlif ədəbiyyatları təhlil edərək, yüksək təzyiqli qolların gətirilmiş həcmi sərtliyinin və hidravlik silindrin gətirilmiş həcmi sərtliyinin ştokun yerdəyişməsindən işçi kameraların həcmlərinin dəyişməsindən asıllıqlarının təyininə yönəlmiş nəticələr verilmişdir.
Açar sözlər: hidravlik sistem, hidravlik intiqal, həcmi sərtlik, hidravlik silindr, modul, boru kəməri, nasos, hidromexanik sistemlər, təzyiq, ştok, dinamika.

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MATHEMATICAL EXPRESSIONS FOR TEMPERATURE IN THE CONTACT ZONE OF TEETH OF THE GEAR MECHANISMS

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ABSTRACT

Transmission gears are very widely used in modern machine building. Despite that electrical transmissions used in machine building industry, mainly mechanical transmissions are widely used in the industry. Because mechanical transmissions are independent and better than other transmisions.
Distributing power between the transmission mechanisms and working units of various machines, changing the angle of momentum, by adjusting the speed of the parts, it is possible to change the type of movement, turn on and off the mechanism, change the direction of the transmission mechanisms.
One of the most widespread types of transmission technology is the gear transmission. Tens of thousands of kilowatt-hours of gears can be transmitted.
Advantages of gear transmission in comparison with others is their ability to maintain their reliability and long term functioning of the teeth, big value of the working coefficient (0,9 ÷ 0,99), simple construction, lack of special service, simplicity of the transmission number and compactness of dimensions.
The missing aspects of these transmissions are high precision in their preparation and installation, and low noise level.
The main criterion for the working ability of the closed gear transmissions is the contact endurance of the active surface of the tooth. For this reason, the main dimensions of the transmission are determined by the contact tension and by teeth bending.
Key words: gear wheel, tension, endurance, bending

Introduction:

In both open and closed transmissions, the tension created by the abrasive particles on the working surfaces, teeth of which not protected from contamination, are subjected to abrasive wear of the teeth.
When the worn teeth gets stuck, the gap between them increases which causes increase of dynamic loads and the noise and the kinematic accuracy of the transmission decreases. This leads to a decrease in the strength and cross-sectional area of the teeth and even to breakage.
In order to prevent corrosion, it is necessary to strengthen the surface of the teeth and reduce their roughness, protect the transmission from abrasive particles, reduce the relative sliding speed in the correction of engagement, and use high-viscosity oils in lubrication.
Task setting. Application of factors affecting the destruction of teeth in gear transmissions.
Task solving. Coefficients affecting the strength of the tooth subjected to dynamic loads.

Main part:

Damage characteristic as overloading, low-speed and medium-speed gears cause wear on the surface of the teeth. Corrosion of the upper surface of the teeth occurs due to the breaking of the oil layer between the touching profiles and the generation of contact stresses between the metal surfaces caused by the effect of high pressure and temperature. If the number of microcontacts

between the touching surfaces is small, then small areas on the upper layer of the teeth are destroyed when the contact is separated, and the temperatures generated in the working profiles are rapidly reduced, the thermal conductivity inside the metal particles and the oil layer between the teeth are restored, and a mild form of tooth wear occurs. Because the metal particles are rubbed off only on one side of the tooth surface, tooth wear occurs gradually.

When the number of microcontacts on the tooth increases, the process of heat release from the surface is delayed, the amount of heat starts to increase during the rotation of the gear, after a certain period of time, the thin layer of oil on the tooth is no longer restored, and as a result of the effect of high temperature, soft metal particles break off from the gear in contact with its tooth profile and stucking to the tooth profile of the other wheel, then forms adhesions between touching surfaces. Bubbles in a hard tooth form grooves in the relatively soft tooth it contacts in sliding, causing the transmission to fail for a short period of time. In addition to choosing a rational material for the gear mechanism, the moment that ensures the prevention of wear on the upper layer of the tooth is the use of special anti-friction oils with the inclusion of highly viscous and chemically active substances.

Plastic sliding deformation can occur on the contact surfaces of the teeth of soft material gears in overloaded transmissions. This sliding leads to a violation of the regularity of the sticking and disintegration of the teeth in the sticking line of the gear teeth.

In order to prevent the occurrence of plastic sliding, it is required to increase the strength of the material of the gear [1].

Low-quality thermal and chemical thermal treatment of the working surface of the teeth sometimes leads to protection of metal particles on the surface of the tooth in the form of a layer. Such cases occur due to defects in the nitrogenized or cemented upper layer of the tooth during teeth grinding, or if the core part of the tooth does not have the required strength, the fragile working surface is compressed under the influence of a large load. One of the causes of rubbing is overloading of the transmission.

The main reason for tooth wear in gears that are sufficiently lubricated and protected from dust and dirt in a closed circuit is the wear and tear of working surfaces due to changing contact stresses.

Abrasion usually occurs due to small cracks at the bottom of the teeth, near the attachment pole. The load is transferred to this zone by only one pair of teeth, in the direction of sliding and rolling of the teeth, the oil is squeezed into the cracks, allowing metal particles to break off. If initial corrosion occurs in the pores caused by defects during the production of wheels, then after a certain period of time, due to this corrosion and plastic deformation, the number of micro-cracks and the concentration of the load decreases, and the pores expand. Such abrasions do not adversely affect the operation of the gear transmission. Small pores formed at the beginning of the attachment line multiply and spread along the working surface of the bottom of the tooth, and sometimes to the top of the tooth.

Although the teeth that wear out without fatigue still retain the ability to stick for a long time in the gear transmission, increased dynamic loads occur that accelerate the disintegration of the teeth in the sticking engagement.

In transmissions teeth of which are subjected to a certain degree of wear, the cracks of which caused by the friction of the upper layers of the tooth do not have the opportunity to expand. In order to prevent rubbing on the surface of the teeth, it is required to report the tolerance according

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to their contact stresses, strengthen the surface of the material and increase the precision in the preparation of gears [2].

Stresses from bending can cause teeth to break. Fracture can occur in two cases, without fatigue and without additional loading.

Fatigue fracture is caused by the disintegration of the base of the tooth under the influence of stresses caused by a large number of repeated loads that exceed the material's endurance limit. Fracture caused by overloading occurs because of static and dynamic forces. Non-fatigue fractures may occur due to improper bending reporting methods, while non-fatigue fractures may occur due to failure of random factors which could cause tooth to be stuck against this load. The gears used in various mechanisms and devices are made of different materials depending on the conditions.

To reduce the weight and reduce the dimensions of the gear, heat-treated alloy steels are preferred. Steel gear teeth can be cut before and after heat treatment. If the teeth are cut after heat treatment, this will not affect the dimensions of the teeth and the accuracy of the transmission. Heat-treated steels are used for teeth cutting in small gears up to HB $\leq$ 350, and in medium and large gears HB < 280.

When choosing gear material and type of heat treatment, the main focus is on increasing the load in the transmission.

The force generated in the sticking causes not only the generation of additional dynamic loads due to the uneven distribution of the load along the contact line, but also the deformation of shafts, bodies and supports [3].

Such loads have a negative effect on the occurrence of certain errors in the installation and preparation of parts included in the transmission.

A number of factors affect the breakdown and failure of teeth during the operation of gear mechanisms.

Most studies show that more than 50% of tooth loss are caused by crooking.

In the reviewed article, the issue of investigating the causes of tooth decay and taking concrete measures to eliminate them was set.

When gears work, heat is released from the heat source along the contact area of the teeth.

Temperatures in the contact area of the teeth in contact increase by approximately 30-40% compared to non-functional areas of the tooth. This causes the working area of the teeth to become even hotter. Under the influence of compressive forces, the temperatures take part in the heating of the teeth again without being able to leave the surface.

In order to determine the distribution of temperatures in the contact areas of the teeth, a metallographic analysis was performed on the structure of the materials.[5]

During the conducted studies, the heat source in the top part of the tooth is considered as a thin-walled part with a displacement speed of Vz=0.001/0.0005 m/sec. and a thickness of 3.5/4.0 mm. For gears with module m= 2-2.5 mm, the temperature from the opposite side of the tooth has its effect on the operation of the tooth.

Studies show that the temperatures generated in contact areas exceed the temperatures of austenitic transformations.

The displacements of the heat source in the contact area of the teeth in gear mechanisms vary according to the sinusoidal law.

The temperatures generated at the base of the tooth are determined by the following formula [4]:

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$$T = \sum_{k=0}^{k=n_1-1} 1{,}3\frac{q_1 a}{\lambda v_z} \cdot \int_{-y-H}^{-y+H} l^{\xi} \cdot K_0\xi \, d\xi$$

$$+ \sum_{k=0}^{k=n_1-1} \frac{q_2 a}{\lambda v_z} \cdot \int_{y-H}^{-y+H} l^{\xi} \cdot K_0\xi \, d\xi + \frac{q_2 a}{\lambda v_z} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi \, d\xi \qquad (1)$$

$$y = [z - (n_1 - k)L] - H$$

Here $z = n_1 \cdot L; n_1 = \frac{\sqrt{D_d \cdot 0{,}7m + (0{,}7m)^2}}{s}$ –is the number of teeth on the gear;

q_1 and q_2- is the intensity of the heat flow generated in the transition from one tooth to another;
a – heat transfer coefficient;
λ – the heat transfer coefficient;
v_z – speed of propagation of the heat source in the head of the tooth;
n – total number of heats;
S – the area of the width of the tooth.
The temperatures generated in the distribution circle of the tooth are determined by the following formula:

$$T = \sum_{k=0}^{k=n_2-1} 1{,}3\frac{q_1 a}{\lambda v_{b\cdot a}} \cdot \int_{-y-H}^{-y+H} l^{-\xi} \cdot K_0\xi \, d\xi +$$

$$+ \sum_{k=0}^{k=n_2-1} \frac{q_2 a}{\lambda v_{b\cdot a}} \cdot \int_{-y-H}^{-y+H} l^{-\xi} \cdot K_0\xi \, d\xi + \frac{q_2 a}{\lambda v_{b\cdot a}} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi \, d\xi \qquad (2)$$

$$y = [z - (n_1 - k)L]$$

$z = n_2 \cdot L; n_2 = \frac{\sqrt{D_d \cdot 0{,}5m + (0{,}5m)^2}}{s}$ v_{bottom}- gear rolling speed on the division circle.

The temperatures generated in the contact zone of the bottom part of the tooth are determined by the following formula:

$$T = \sum_{k=0}^{k=n_3-1} 1{,}3\frac{q_1 a}{\lambda v_{bottom}} \cdot \int_{-y-H}^{-y+H} l^{-\xi} \cdot K_0\xi \, d\xi + \frac{q_2 a}{\lambda v_{bottom}} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi \, d\xi \qquad (3)$$

$$z = n_3 \cdot L; n_3 = \frac{\sqrt{D_d \cdot h + h^2}}{s}$$

h □ 0,5 □ 0,7 mm, for instrumentation $h = \sqrt{Dd \cdot t}$

The above equations allow measuring the temperatures in the contact areas of all types of gears. Let's consider the formulas that determine the temperatures for gears with a contact cut at an angle of 15^0:

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The temperatures generated in the contact zone of the base of the tooth are determined by the following formula:

$$T= 1{,}3\frac{q_1 a}{\lambda v_{top}} \cdot \int_{y_1-H}^{y_1+H} l^{-\xi} \cdot K_0\xi \, d\xi + \frac{q_2 a}{\lambda v_{top}} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi \, d\xi \quad (4)$$

$$y_1 = 6H$$

The temperature generated in the distribution circle of the tooth is determined by the following formula:

$$T= \frac{q_1 a}{\lambda v_{d.c.}} \cdot \int_{y_2-H}^{y_2+H} l^{-\xi} \cdot K_0\xi \, d\xi + \frac{q_2 a}{\lambda v_{d.c.}} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi \, d\xi \quad (5)$$

$$y_2 = (2m + 5h) \cdot \frac{v_{or}}{2a}, \; v_{or} = \frac{v_{top}+v_{d.c.}}{2}$$

The temperatures generated in the root part of the tooth are determined by the following formula:

$$T= \sum_{k=0}^{k=n_3-1} \frac{q_1 a}{\lambda v_{bottom}} \cdot \int_{y_3-H}^{y_3+H} l^{-\xi} \cdot K_0\xi \, d\xi + \frac{q_2 a}{\lambda v_{bottom}} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi \, d\xi \quad (6)$$

$$y_3 = (2{,}2m + 2h) \cdot \frac{v_{or}}{a}, \; v_{or} = \frac{v_{bottom}+v_{top}+v_{d.c.}}{3}$$

Equations that determine temperatures in the contact zone of gears with a contact profile used in devices:

$$T= 1{,}3\frac{q_1 a}{\lambda v} \cdot \int_{y_4-H}^{y_4+H} l^{-\xi} \cdot K_0\xi \, d\xi + \frac{q_2 a}{\lambda v} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi \, d\xi \quad (7)$$

$$y_4 = 5H$$

Cracks are often formed on the side surfaces of the gear profiles due to friction. It is necessary to control the heat intensity of the process in order to eliminate the defects caused by the increase of temperatures in the contact areas of the gears during transmission. Therefore, the temperatures generated in the contact zone are expressed as follows [6,7]:

$$T= \frac{qa}{\lambda v_c} \cdot \int_{-y-H}^{-y+H} l^{-\xi} \cdot K_0\xi^2 \, d\xi + \frac{qa}{\lambda v_ç} \cdot \int_{-2H}^{0} l^{-\xi} \cdot K_0\xi^2 \, d\xi \quad (8)$$

$H = \frac{h \cdot v_c}{2a}$ - the dimensionless half-width of the source;

$q = \frac{P_z \cdot V_d}{S}$ - the heat flow intensity;

λ – = the heat transfer coefficient;

$$y = \frac{v_c}{a}\sqrt{D_d \cdot 2{,}2m + (2{,}2m)^2}$$

K_0- the first type is the Bessel function.

From the results of the research, it was determined that the temperatures generated in the contour areas of the teeth exceed the temperatures of the austenite, which strengthens the tooth, and these temperatures reach 800-1300^{0}C at the top and bottom of the tooth. The obtained results were

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confirmed as a result of metallographic studies. The percentage of carbon at the initial and final temperatures of martensite transformation has beem determined (Figure 1).

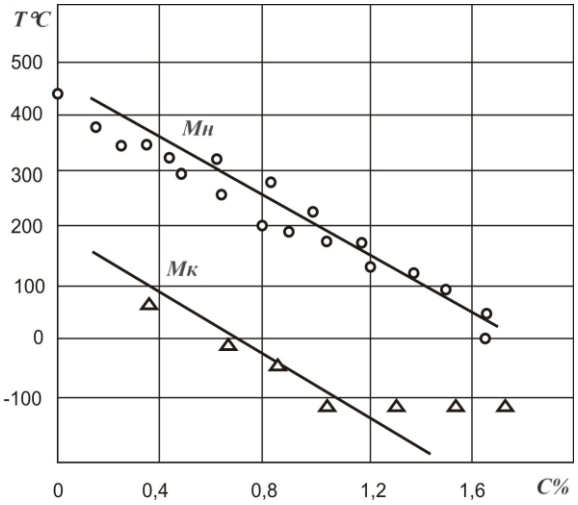

Figure 1: A graph showing the dependence of the initial and final temperatures of martensite transformation on the percentage of carbon

With the percentage of carbon being C = 0.8%, the starting temperatures for transformation to martensenite are 250 °C. Since the percentage of carbon is C = 1.3%, the starting temperature of transformation to martensite is 100°C.

When the percentage of carbon is C ≈ 1.3 -1.4%, the initial temperatures in the transformation to martensite are 70^0-100^0C. During the subsequent cooling stages, the temperature was lowered from 850^0 to 100^0C and the formation of temporary thermoelastic stresses on the surface has been observed (Figure 2).

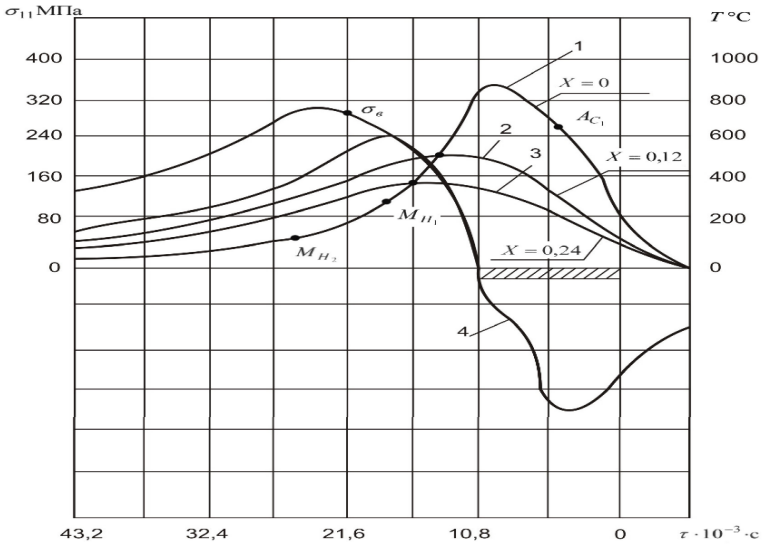

Figure 2: The nature of the temperature change on the contact surfaces of the tooth and the curve of the change of the temporary thermoelastic stresses during the cooling stages.

Temporary thermoelastic stresses increase up to the initial temperatures in the martensenite transformation. After the martensenite transformation point, the temporary thermoelastic stresses decrease and the process is accompanied by an increase in the volume of the surface material structure.

The following results have been obtained from the conducted theoretical studies.

Conclusions

1. The cause of damage on the working surface of the teeth are the variable contact stresses and the friction created in the profiles of the teeth.
2. It was determined that the areas of microcracks in the tooth layer between the touching surfaces are disintegrated and that corrosion occurs between the touching profiles due to the effect of high pressure and temperatures.
3. Deriving of the equations that determine the temperatures generated at the top, division part and root of the tooth has been determined.
4. In order to prevent the top layer of the tooth from being worn, it is considered appropriately to use special anti-rubbing oils with the inclusion of high viscosity and chemical substances.

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DİŞLİ ÇARX MEXANİZMLƏRİNDƏ DİŞLƏRİN TOXUNMA SAHƏLƏRİNDƏ YARANAN TEMPERATURLARIN YAZILIŞINI TƏMİN EDƏN TƏNLİKLƏR

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XÜLASƏ

Hal-hazırda maşınqayırma sənəyesində ən çox istifadə olunan mexanizmlər ötürmə mexanizmləridir. Müasir maşınqayırmada elektrik tipli ötürmələrdən istifadə olunmasına baxmayaraq mexaniki

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ötürmələrdən daha çox istifadə olunur. Mexaniki ötürmələr həm müstəqil işlayir, həm də digər ötürmələrə yardımçı olur.
Ötürmə mexanizmləri ilə müxtəlif maşınların işçi orqanları arasında enerjini paylamaq, dövrlər sayını azaltmaq və ya artırmaqla burucu momenti dəyişmək, ötürməyə daxil olan hissələrin sürətlərini tənzimləmək, hərəkətin növünü dəyişmək, mexanizmi işə salmaq, söndürmək və ötürücü mexanizmlərin hərəkət istiqamətini dəyişmək olar.
Ötürmə mexanizmlərinin texnikada ən geniş yayılmış növlərindən biri də dişli çarx ötürməsidir. Bu ötürmə növü ilə on minlərlə kilovatt gücü ötürmək mümkündür.
Dişli çarx ötürmələrinin digar ötürmələrə nisbətən üstün cəhəti onların böyük gücü ötürə bilməsi, dişlərdəki ilişmənin etibarlılığını və uzun müddətə işləmə qabiliyyətini saxlaması, faydalı iş əmsalının böyüklüyü (0,9 ÷ 0,99), ötürmənin sadə konstruksiyada hazırlanması, xüsusi qulluğa ehtiyacın olmaması, ötürmə ədədinin sabit qalması va əndazə ölçülərinin yığcam olmasıdır.
Qapalı dişli çarx ötürmələrinin işləmə qabiliyyətinin əsas meyarı dişlərin aktiv səthinin kontakt dözümlülüyü hesab olunur. Bu səbəbdən də ötürmənin əsas ölçüləri kontakt gərginliklarinə görə hesabatlardan təyin olunaraq çarxın dişləri əyilməyə yoxlanılır.
Baxılan məqalədə dişli çarxın yeyilməsinə və dağılmasına ən çox təsir edən faktorlardan biri kimi dişlərin toxunan səthlərində yaranan temperaturların dişin profilinə təsirinə baxılmışdır.
Açar sözlər: dişli çarx, gərginlik, dözümlülük, əyilmə.

МАТЕМАТИЧЕСКИЕ ВЫРАЖЕНИЯ ТЕМПЕРАТУРЫ В ЗОНЕ КОНТАКТА ЗУБЬЕВ ЗУБЧАТЫХ МЕХАНИЗМОВ

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РЕЗЮМЕ

Передаточные механизмы очень широко используются в современном машиностроении. Несмотря на то, что в машиностроении используются электрические трансмиссии, в промышленности широко применяются в основном механические трансмиссии. Потому что механические трансмиссии независимы и лучше других трансмиссий.
Распределяя мощность между передаточными механизмами и рабочими органами различных машин, изменяя угол импульса, регулируя скорость движения деталей, можно менять вид движения, включать и выключать механизм, менять направление передачи механизма.
Одним из наиболее распространенных видов трансмиссионной техники является зубчатая передача. Позволяющая передавать десятки тысяч киловатт-часов передач.
Преимуществами зубчатых передач по сравнению с другими являются их способность сохранять свою надежность и длительный срок работы зубьев, большое значение рабочего коэффициента (0,9 ÷ 0,99), простота конструкции, отсутствие специального обслуживания, простота устройства. число передач и компактность габаритов.
Недостающими аспектами этих трансмиссий являются высокая точность их подготовки и установки, а также низкий уровень шума.

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Основным критерием работоспособности замкнутых зубчатых передач является контактная выносливость активной поверхности зуба. По этой причине основные размеры передачи определяются контактным напряжением и изгибом зубьев.
Ключевые слова: зубчатое колесо, натяжение, допуск, изгиб.

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INFLUENCE OF THE METHOD OF ELECTROLYTIC POLISHING, MECHANICAL TREATMENT AND PURITY OF THE BASE METAL SURFACE ON THE STRENGTH OF BONDING BY ELECTROLYTIC DEPOSITS OF IRON

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ABSTRACT

In the present work, the influence of the composition of the electrolyte and the duration of electropolishing of the base metal on the strength of adhesion to iron deposits was studied, and the method of mechanical treatment before applying electrolytic coatings was shown to determine not only the microgeometry of the surface, but also the physicochemical state of the metal in the surface layer, thereby affecting the protective properties. oxide film. On the other hand, the type of machining affects the cost of restoring and coating parts. Therefore, it is practically important to determine the effect of the method of machining and the surface finish of the base metal on the adhesion strength with electrolytic iron deposits.

Along with mechanical action, chemical processes play an important role in polishing. The surface of the metal is covered with thin, invisible oxide or salt films under the influence of the environment and the chemically active substances contained in the polishing pastes. When polishing, the film is removed, but on the exposed areas of the metal it is formed again. The hardness of abrasive grains during polishing is not as important as during grinding, since in the first case the abrasive removes a thin film that is less durable than metal.

In the process of manufacturing parts by mechanical polishing, traces of processing in the form of small irregularities remain on their surface. The magnitude of these microroughness's determines the surface finish of the parts. This characteristic has a great influence on the quality of the finish and the performance properties of the products. The smoother the metal surface, the better it resists corrosion.

Improving the surface finish increases the wear resistance of the parts. Obtaining shiny surfaces is also associated with the need to remove microroughness.

It has been determined that the cleanliness of the surface treatment of parts before electroplating is determined by their purpose and type of coating. Surface cleanliness depends on how the parts are prepared before electroplating. Polishing products with a lower initial surface finish significantly increases the processing time, which reduces the productivity of the equipment.

It has been established that electrochemical and chemical polishing have several advantages over mechanical polishing. They do not require the physical effort of the worker, which reduces the

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complexity of finishing operations. Many products of various shapes and sizes can be processed simultaneously, which is not feasible when polishing with circles.

Electrochemical polishing has become more widespread in industry. With its help, a greater smoothing and more intense gloss of the metal surface is achieved than with chemical polishing. The use of this process in preparation for electroplating reduces the number of operations and transitions and improves product quality by increasing the adhesion strength of the coating to the base metal.

Keywords: Machining, surface finish, electropolishing, electrolyte, roughness, adhesive strength, iron precipitation, iron plating.

Introduction. The technological process of ironing has much in common with the technological process of chromium plating. It also consists of three stages: preparation of parts for coating, application of coating, and processing of parts after coating.

Mechanical preparation of products before electroplating is carried out in order to improve the surface finish [1] (according to GOST 2789), remove irregularities, nicks, corrosion products, and impart shine to the metal. The main methods of mechanical preparation of products are grinding and polishing on wheels or hydro abrasive processing.

The main purpose of machining the surface of a part is to obtain a homogeneous structure, in contrast to chromium plating, where it is performed to obtain the correct geometric shape of the surface of the part. This is because in operation hardening is formed on certain parts of the part surface, which can lead to uneven etching during pickling and peeling of the coating on certain parts of the part surface.

Grinding is usually carried out on a machine, on the rotating spindle of which a circle is fixed. Circles are used in two types; hard ones made of abrasives and circles made of elastic material, on the working surface of which abrasive grains are applied. Wheels of the first type are used relatively little, mainly for peeling and deburring. Circles of the second type are very widely used to smooth the surface of the metal. When grinding, the sharp edges of the abrasive grains of the wheel remove thin metal chips from the parts. Depending on the material of the wheel, the grain size and the amount of binder, a greater or lesser smoothing of the surface is achieved [2].

Polishing is carried out on the same machines as grinding, using elastic wheels. A thin layer of polishing paste is applied to the working surface of the wheel, consisting of a fine abrasive, a fatty binder and special additives. In this case, smoothing occurs not due to chip removal, but due to deformation of metal crystals and erasure of protruding particles. Polishing is accompanied by much less metal removal than grinding.

Processing in drums allows you to clean the surface of the part from contamination, smooth out its irregularities and impart shine to it. For grinding, the parts are loaded into a rotating drum. Simultaneously with the parts, an abrasive is loaded into the drum: emery, corundum, quartz sand, lime. By replacing the coarse abrasive with polished steel balls, pieces of wood, felt or leather, a higher quality of work is achieved, the parts are polished. The use of drums for grinding and polishing is a proven and reliable means of mechanizing and reducing the labor intensity of mechanical preparation, since it makes it possible to process a large number of parts simultaneously, without the use of manual labor.

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Chemical and electrochemical polishing are considered very promising methods. Even though in electrochemical polishing metal is processed using electric current, and in chemical polishing without it, these processes have much in common.

In both cases, the surface of the metal becomes shiny. The appearance of gloss is associated with the formation of a thin oxide film on the metal, which prevents or limits the etching effect of the solution on the metal.

The film thickness is not the same: it is less on micro protrusions and more on microcavities. Therefore, the solution acts primarily on micro protrusions, and they dissolve faster than the rest of the metal. This is also facilitated by the viscous salt layer formed because of the reaction of the metal with the solution, which is retained in the microcavities of the surface. The result of these processes is the smoothing of the smallest irregularities of the metal surface.

Purpose of the study. Influence of the composition of the electrolyte and the duration of electropolishing of the base metal on the strength of adhesion to iron deposits.

Research Methodology. For the study, a part of the gate used in direct-flow valves was chosen [3]. This part (Fig. 1) is usually made of steel grade 40X or 38X2MЮA.

It is very important to choose the right surface for cutting the sample and to prepare the cut for the correct examination. It was carried out according to the procedure for preparing thin sections [4]. The preparation of sections was carried out on a grinding and polishing machine (Fig. 2).

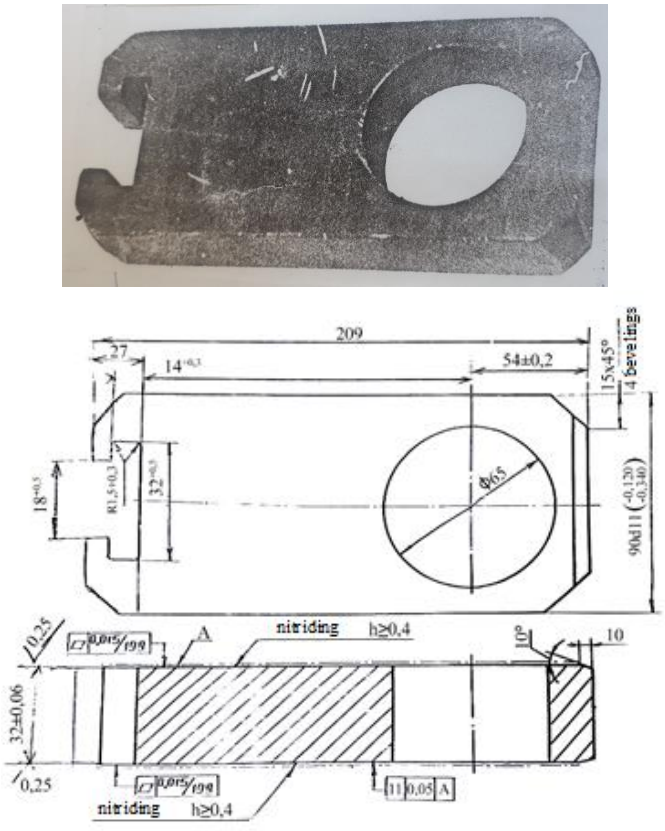

Figure 1: General view and working drawing of the gate

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Figure 2: Sanding-polishing machine

Electrochemical polishing is carried out in an electrolyte bath. The sample is connected to the anode. The cathode is made from a thin stainless steel plate. When direct current is released from the electrolyte, the anode begins to melt. After polishing, fine lines and protrusions remaining on the surface of the sample disappear, and a smooth and shiny surface is obtained like a mirror (Fig. 3).

The amount of electrolyte for electrochemical polishing of steel taken for each determination is calculated by the formula:

$$n = \frac{m \cdot 20}{200} \quad (1)$$

Where, m -is the amount of electrolyte taken for dilution, gr; n -is the amount of electrolyte taken for each determination, gr.

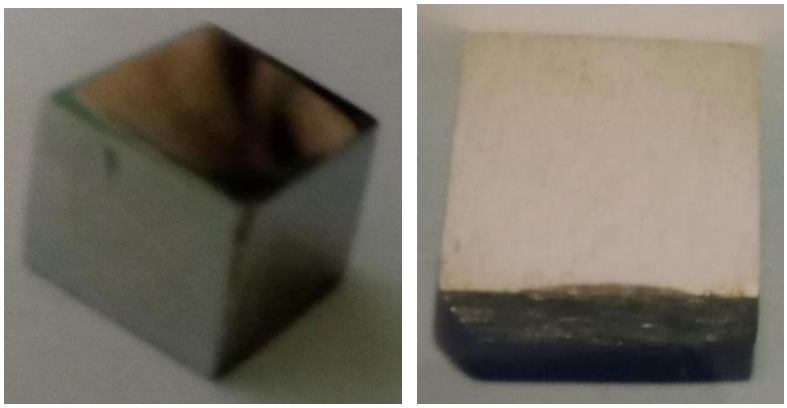

Figure 3: The appearance of the steel surface after various machining: left-grinding; right-polishing

Surface cleanliness is determined by the average height of microroughness's H_a or the root-mean-square deviation from the average line of the microroughness profile H_d. The maximum microroughness height H_{max} can also be determined. A schematic representation of the surface micro profile is given in fig. 4.

GOST 2789 indicates 14 purity classes, which cover the range of microroughness's with a height of 200 microns (for the first class) to 0.06 microns (for the fourteenth class) [5].

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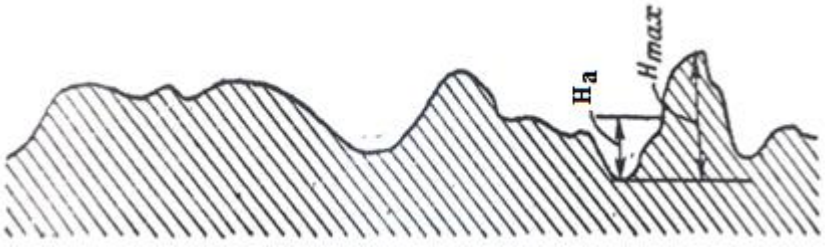

Figure 4: Schematic representation of the micro profile of the metal surface.

Surface cleanliness is controlled using special instruments that allow visual or graphical examination of the surface micro profile. In electroplating shops, to assess the cleanliness of the processing of parts, it is usually sufficient to compare them with reference samples.

Machining before phosphating can be limited to the 4th-6th class, and before oxidation to the 6th-10th class. It is advisable to apply matte and semi-gloss coatings on parts with a surface finish of 4-7th class. To obtain shiny coatings, the surface cleanliness must be at least 9-10th grade [6].

Grinding with abrasives with a grain size of 30-220 produces a surface finish corresponding to the 6-10th grade, and the greatest smoothing occurs when metal is processed with abrasives with a grain size of 30-100. Brushing products with a surface finish of class 5-8 leads to an increase in its average by one class. Brushing more cleanly finished products degrades the surface quality. By polishing on wheels with pastes, the surface cleanliness increases from 7-9th to 10-13th grades.

Chemical methods of preparation of products affect the purity of the metal surface much less than mechanical methods. Etching of ferrous metals increases the surface cleanliness by an average of half a class. In case of poisoning of rolled products and castings, the surface cleanliness may deteriorate due to the detection of irregularities hidden under the scale.

Electrochemical polishing of carbon steel in a chromium-sulphur-phosphorus electrolyte increases the surface cleanliness of products with an initial cleanliness of their 4-7th grade by 1 class, with an initial cleanliness of 8-10th grade by 2 classes. Therefore, it is advisable to use electrochemical polishing for decorative finishing of products with an initial surface frequency of at least 8-9th grades [7].

Electrochemical polishing of 40X steel samples in phosphoric acid electrolytes containing chromic anhydride occurs under a regime corresponding to the section of the curve above point d, and is accompanied by oxygen evolution. This process is characterized by a wide range of operating current density. Small deviations from the set values do not affect the quality of polishing. Under such conditions, the mode of electrolysis is determined by the current density.

Chemical polishing does not require the use of electric current, which simplifies its use in production. The disadvantages of this process include the difficulty of adjusting the solutions and the short period of their action. It is not possible to obtain an intense gloss of the metal surface. It is advisable to subject brass and aluminum products of complex shape and small sizes to chemical polishing, which do not require a mirror surface.

Electrochemical polishing, applied as the final operation of the technological process, passivates the metal surface, which leads to an increase in the resistance of products against corrosion.

It is indicated that “electrolytic polishing is an excellent tool for ensuring perfect adhesion between the base metal and electroplated coatings”. The ratio of the amount of actually

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precipitated metal to the theoretically possible one is called the metal yield to the flow process efficiency [8, 9, 10].
The thickness of the deposited metal layer is determined by the formula (Fig. 5):

$$b = c \cdot D_c \cdot t \cdot n/100\gamma \quad (2)$$

where, D_c -is the current density, A/dm^2; n -is the current output of the metal; γ -is the density of the deposited metal, gr/sm^3.
With a given thickness of the metal layer, the duration of the process can be determined by the formula.

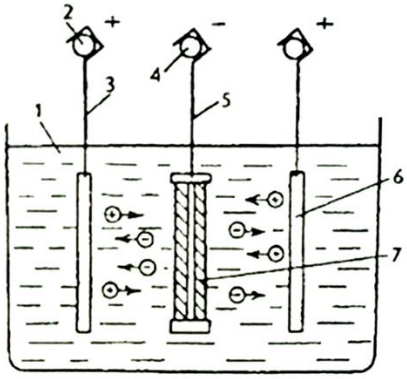

Figure 5: Scheme of electrolytic metal deposition: 1-bath; 2-anode rod; 3-suspension for anode plates; 4 cathode rod; 5-suspension for details; 6-anode; 7-piece (cathode)

Results and Discussion. The effect of the composition of the electrolyte and the duration of electropolishing of the base metal on the strength of adhesion to iron deposits was studied in this work. The results of the study are presented in fig. 6.
The maximum adhesion strength of the base metal with iron deposits (154 MPa) is provided by electrolytic polishing in an electrolyte of the composition:
phosphoric acid - 55%;
sulfuric acid - 21 %
chromic anhydride - 2%
water- 22%
in electrolysis mode:
anode current density - D_a= 38-40 A/dm^2;
electrolyte temperature - t = 73-75°C;
polishing time - T= 9-10 min.
After electropolishing, pickling was carried out in a 5% H_2SO_4 solution for 3-4 seconds to improve bond strength.
The process of electrolytic polishing proceeds under conditions similar to the anodic passivation of metals. With the optimal composition of the electrolyte and the process mode, oxide films are dissolved, and the microstructure of the base metal is revealed (Fig. 7). The high strength of adhesion to iron deposits can be explained by the fact that a viscous film of anodic etching products protects the electropolished surface from the oxidizing action of air oxygen and when interacting with chloride electrolyte. The passive film does not interfere with the process of

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electro crystallization of iron on the surface of the base metal freed from the oxide layer (Fig. 8, a).

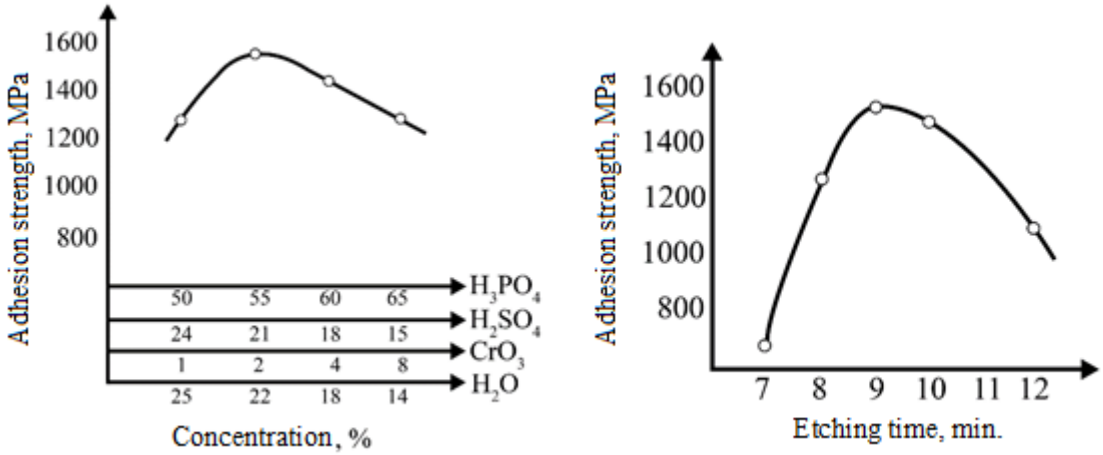


Figure 6: Dependence of the adhesion strength of iron deposits on electropolishing in electrolytes of various compositions (a) and the duration (b) of polishing in electrolyte, composition: H_3PO_4, - 55%; H_2SO_4, - 21%; CrO_3 - 2%; H_2O - 22%

It should be noted that even with a significant thickness of the deposited iron layer (up to 0.7-0.8 mm) on the electropolished base metal, the coating has a high surface quality and does not require subsequent machining (Fig. 8, b, c).

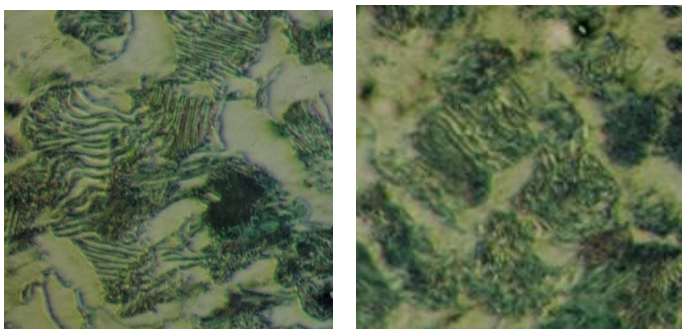
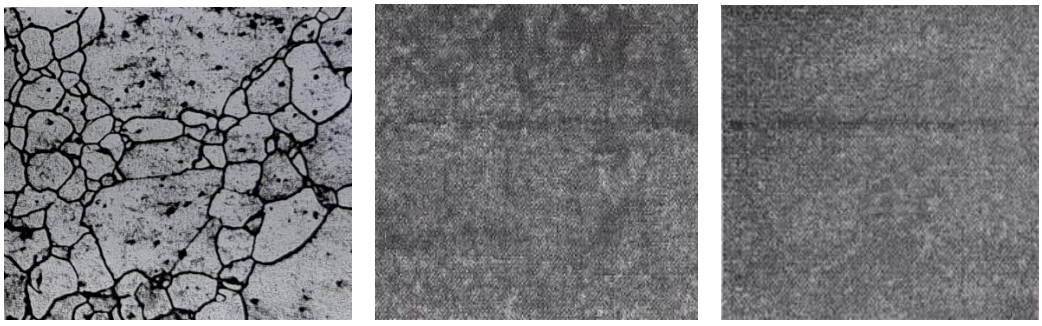


Figure 7: Microstructures of the base metal, x500: a-40X; b-38X2MЮA



a b c

Figure 8: The nature of the "transition zone" between the iron coating and the base metal during electrolytic polishing in phosphorus-sulphur-chromium electrolytes:

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a-microstructure of iron coatings; b-to polishing; c-after polishing.

The method of mechanical treatment before applying electrolytic coatings determines not only the microgeometry of the surface, but also the physicochemical state of the metal in the surface layer, thereby affecting the protective properties of the oxide film. On the other hand, the type of machining affects the cost of parts. Therefore, it is practically important to determine the effect of the method of mechanical treatment and the purity of the surface of the base metal on the strength of adhesion to electrolytic deposits of iron.

The following methods of machining, which are widely used for coating and restoration, were studied in the work: 1) turning according to 4, 5, 6, 7 classes; 2) grinding on 6, 7, 8, 9 classes; 3) fine-tuning according to 9, 10, 11, 12 surface cleanliness classes according to GOST 2789. The surface cleanliness was controlled using an Abris PM7M profilometer.

Electrochemical etching was carried out in an electrolyte of optimal composition: in a 30% sulfuric acid solution and the process mode D_a = 20 A/dm^2 and T = 3 min. The results obtained are presented in fig. 9.

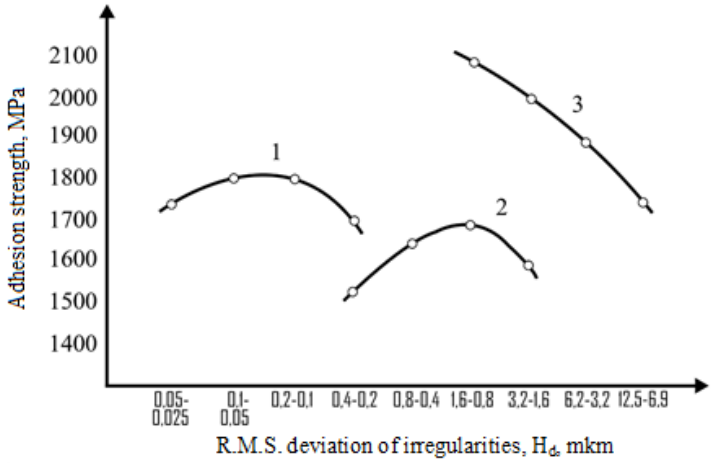

Figure 9: Dependence of the adhesion strength of iron deposits on the standard deviation of the surface irregularities of the base metal: 1-finishing; 2-grinding; 3-turning

When conducting research, it was found that the adhesion of iron deposits largely depends on the method of machining the base metal. As can be seen from fig. 9, for each method of machining, there is its own optimal surface frequency, which provides maximum adhesion strength to the iron coating (Fig. 10 a, b, c). When turning according to the 7th class of surface cleanliness, the adhesion strength is 2000-2100 MPa, and when grinding, for the same class, it decreases to 1700 MPa. When tested by the "bushing pressing" method (for shear), the adhesion strength increases with increasing surface finish and is 3690 MPa when turning according to class 7. The polished surface of the base metal has a higher adhesion to iron deposits than the polished surface, even within the same class of surface cleanliness. The decrease in the strength of adhesion to the electrolytic iron coating during grinding can be explained by significant deformation and destruction of the surface layer of the base metal from the impact of the grinding wheel.

A lower degree of deformation during finishing causes a greater adhesion strength with iron deposits than during grinding. Finishing on the surface for the application of electrolytic coatings is advisable up to class 10 cleanliness. With a further increase in the quality of the surface, the adhesion to iron deposits decreases, and the cost of processing increases sharply.

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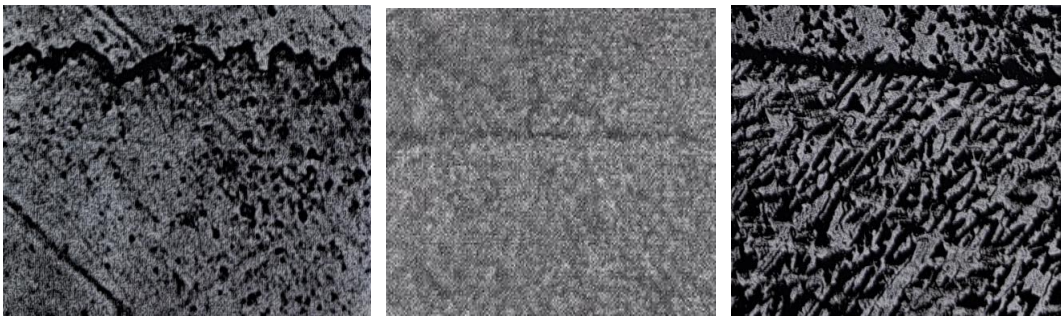

a b c

Figure 10: The nature of the "transitional zone" between the iron coating and the base metal, depending on the method of machining and surface finish: a-turning; b-grinding; c -finishing

Conclusions

It was determined that during the manufacture of parts by mechanical polishing, traces of processing in the form of small irregularities remain on their surface, and the magnitude of these microroughnesses determines the cleanliness of the surface of the parts.

The determination of the influence of the methods of mechanical processing and the purity of the surface of the base metal on the strength of adhesion to electrolytic deposits of iron has been studied.

The nature of the "transition zone" between the iron coating and the base metal during electrolytic polishing in phosphorus-sulphur-chromium electrolytes, depending on the method of machining and surface finish, has been studied.

The dependence of the adhesion strength of iron deposits on electropolishing in electrolytes of various compositions and the duration of polishing in an electrolyte has been studied. Due to the fact that, in addition to the metal, hydrogen is released on the cathode and other processes take place, the amount of actually deposited metal compared to the theoretically possible one is called the current efficiency of the metal or efficiency process. The thickness of the deposited metal layer is determined by the formula. With a given thickness of the metal layer, the duration of the process can be determined by the formula.

It has been researched that electropolishing is an excellent means to ensure a perfect bond between base metal and plating. For each method of machining before coating, there is an optimal surface finish that provides maximum adhesion to iron deposits:

a) turning according to the surface finish class for non-heat-treated steels;

b) grinding according to the 8th class of surface cleanliness (GOST 2789) for hardened steels.

The dependence of the adhesion strength of iron deposits on the standard deviation of surface irregularities and electropolishing of various compositions and duration of polishing was studied. During the test, it was found that the parts of the fittings valves, restored by ironing, have a reliable adhesion of the iron coating to the base metal.

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ВЛИЯНИЕ СПОСОБА ЭЛЕКТРОЛИТИЧЕСКОГО ПОЛИРОВАНИЯ, МЕХАНИЧЕСКОЙ ОБРАБОТКИ И ЧИСТОТЫ ПОВЕРХНОСТИ ОСНОВНОГО МЕТАЛЛА НА ПРОЧНОСТЬ СЦЕПЛЕНИЯ ЭЛЕКТРОЛИТИЧЕСКИМИ ОСАДКАМИ ЖЕЛЕЗА

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РЕЗЮМЕ

В настоящей работе исследовалось влияние состава электролита и продолжительности электрополирования основного метала на прочность сцепления с осадками железа и показано способ механической обработки перед нанесением электролитических покрытий определяет не только микрогеометрию поверхности, но и физико-химическое состояние металла в поверхностном слое, влияя тем самым на защитные свойства оксидной пленки. С другой стороны, вид механической обработки сказывается на стоимости восстановление и покрытие деталей. Поэтому практически важным является определение влияние способа механической обработки и чистоты поверхности основного металла на прочность сцепления с электролитическими осадками железа.

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Наряду с механическим воздействием большую роль при полировании играют химические процессы. Поверхность металла под влиянием окружающей среды и содержащихся в полировочных пастах химически активных веществ покрывается тонкими, невидимыми окисными или солевыми пленками. При полировании пленка снимается, но на обнажившихся участках металла образуется вновь. Твердость абразивных зерен при полировании не имеет такого большого значения, как при шлифовании, так как в первом случае абразив снимает тонкую пленку, менее прочную, чем металл.

В процессе изготовления деталей механической полировкой на их поверхности остаются следы обработки в виде мелких неровностей. Величина этих микронеровностей и определяет чистоту поверхности деталей. Эта характеристика оказывает большое влияние на качество отделки и эксплуатационные свойства изделий. Чем больше гладкость поверхности металла, тем лучше он противостоит коррозии.

Повышение чистоты поверхности увеличивает износостойкость деталей. Получение блестящих поверхностей также связано с необходимостью удаления микронеровностей.

Определено что, чистота обработки поверхности деталей перед гальваническим покрытием определяется их назначением и видом покрытия. Чистота поверхности зависит от способа подготовки деталей перед гальваническими покрытиями. Полирование изделий с более низкой начальной чистотой поверхности значительно увеличивает продолжительность обработки, что снижает производительность оборудования.

Установлено что, электрохимическая и химическое полирование имеют ряд преимуществ по сравнению с механическим. Они не требуют затраты физических усилий рабочего, что снижает трудоемкость отделочных операций. Одновременной обработке может подвергаться большое количество изделий различной формы и габаритов, что неосуществимо при полировании кругами.

Большее распространение в промышленности получило электрохимическое полирование. С его помощью достигается большее сглаживание и более интенсивный блеск поверхности металла, чем при химическом полировании. Применение этого процесса при подготовке к гальваническим покрытиям уменьшает количество операций и переходов и улучшает качество продукции за счет повышения прочности сцепления покрытия с основным металлом.

Ключевые слова: Механическая обработка, чистота поверхности, электрополирования, электролит, неровность, прочность сцепления, осадка железа, железнение.

ƏSAS METAL SƏTHİNİN ELEKTROLİTİK CİLALAMA, MEXANİKİ EMAL VƏ TƏMİZLİK ÜSULLARININ ELEKTROLİTİK ÇÖKDÜRÜLMÜŞ DƏMİRİN İLİŞMƏ MÖHKƏMLİYİNƏ TƏSİRİ

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XÜLASƏ

Hal-hazırkı işdə elektrolitik tərkibin və əsas metala elektro-cilalama vaxtının çökdürülmüş dəmirin ilişmə möhkəmliyinə təsiri və elektrolitik örtüyün yaradılmasından qabaq göstərilən mexaniki emal üsulu təkcə səthin mikrohəndəsəsini yox, həmçinin səth qatında metalın fiziki-kimyəvi vəziyyətini müəyyən etməklə bərabər oksid pərdəsinin qoruyucu xüsusiyyətləri təsir edir. Digər tərəfdən mexaniki emal üsulları detalların örtük və bərpa dəyərlənməsindən xəbər verir. Buna görə də elektrolitik çökdürülmüş dəmirin ilişmə möhkəmliyinə əsas metal səthinin təmizlik və mexaniki emal üsullarının təsirinin müəyyən edilməsi təcrübi cəhətdən çox əlverişli sayılır.
Mexaniki təsirlərlə yanaşı cilalamada kimyəvi proseslər böyük rol oynayır. Xarici ətraf mühitin təsiri altında və cilalayıcı yaxtılarda kimyəvi aktiv maddələrlə metal səthi nazik, görünməyən oksidlərlə yaxud duz pərdəsi ilə örtülür. Cilalama zamanı abraziv dənələrinin bərkliyi bir o qədər də əhəmiyyət kəsb etmir, necə ki, pardaxlama zamanı. Beləliklə, birinci halda abraziv metaldan az möhkəm, nazik qatı çıxarır.
Detalların mexaniki cilalama ilə hazırlama prosesində onların səthində emal izləri xırda kələ-kötürlük şəklində qalır. Bu kələ-kötürlük kəmiyyətləri detal səthinin təmizliyini müəyyən edir. Bu xarakteristika hissələrin keyfiyyətinə və məmulatının istismar xassələrinə çox təsir edir.
Metalın səthi nə qədər hamar (sığallı) olarsa, bir o qədərdə o korroziyaya əks müqavimət göstərir. Səthin təmizliyinin artırılması detalların yeyilməyədavamlılığını yüksəldir.
Müəyyən edilmişdir ki, detalların səthinin emal təmizliyi qalvanik örtmədən qabaq onların təyinatı və örtük növü ilə müəyyən edilir. Səthin təmizliyi qalvanik örtmədə qabaq detalın hazırlanma üsulundan asılıdır. Məmulatın cilalanması nisbətən aşağı səth təmizliyində olması emal davamiyyətini artırır ki, bu da avadanlığın məhsuldarlığını azaldır.
Qərarlaşdırılmışdır ki, elektrokimyəvi və kimyəvi cilalama mexanikiyə nisbətən bir sıra üstünlüklərə malikdir. Onlar fəhlənin fiziki güc sərfini tələb etmir ki, bu da ayrı-ayrı əməliyyatlar üzrə əmək tutumunu azaldır. Çoxlu sayda müxtəlif formalı məmulatların eyni zamanda emala uğradılır ki, bunun da cilalama daşları ilə yerinə yetirilməsi mümkün deyil.
Sənayedə çoxlu yertutmasına görə elektrokimyəvi cilalama ən geniş yer alır. Onun köməyilə kimyəvi cilalamaya nisbətən metal səthində böyük sığallılıq (hamarlılıq) və daha intensiv səth parlaqlılıq əldə edilir.
Qalvanik örtməyə (çökdürməyə) hazırlıq zamanı bu prsesin tətbiqi əməliyyatları, keçidlərin sayını azaldır və örtük ilişmə möhkəmliyini yüksəldilməsi hesabına keyfiyyəti yaxşılaşdırır.
Tədqiqatın aparılması zamanı aşkarlanmışdır ki, çökdürülən dəmirin ilişmə möhkəmliyi əsas metalın mexaniki emal üsulundan əhəmiyyətli dərəcədə asılıdır.
Elektrolitik dəmir örtüyün ilişmə möhkəmliyinin azalması pardaxlama zamanı xeyli deformasiyalarla və əsas metalın səth qatının pardaxlama daşının (dairəsinin) təsirindən dağılması ilə izah edilə bilər. Tərkibə çatdırma zamanı deformasiyanın aşağı dərəcəsi dəmir çökdürülmüş dəmirin böyük ilişmə möhkəmliyinin artmasına şərait yaradır, nəinki prdaxlama.
Açar sözlər: Mexaniki emal, səthi təmizlik, elektrocilalama, elektrolit, kələ-kötürlük, ilişmə möhkəmliyi, dəmir çöküntüsü, dəmirləmə.

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PRIMARY OIL REFINING AND HEAT EXCHANGER APPARATUS

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ABSTRACT

Different technological processes are applied in the field of modern oil refining. Each of the processes in turn is implemented by many technological schemes and methods. In petroleum refining and chemical production, these technological processes provide the basis for many simple processes. In this way, the learning of the processes is facilitated. They process oil and its products by applying various processes.
Oil refining and its main organic synthesis plants are composed of a collection of various technological processes and general plant farms. Depending on the number and quality of the products received from the factories, great attention is paid to the supply of hardware and equipment. It is through these equipment and devices that technological processes are carried out. Heat exchangers are among the most commonly used devices in the oil refining industry. The most common type of heat exchangers are shell-and-tube heat exchangers. Shell and tube heat exchangers are technological in the oil and gas industry pretreatment to improve properties and reduce viscosity of streams stages are widely used.
Distribution of shell-and-tube heat exchanger design reliability and due to the variety of types and versions to work in a wide range of temperature, pressure and corrosive environment.
At the current stage of production development, an important trend is increasing the efficiency of the used technological equipment, ensuring high energy efficiency in relation to heat exchange equipment.
Flat cross-sections of different configurations are used to organize the cross current in the inter-tube space of the heat exchanger and to increase the cooling speed. The presence of such partitions significantly complicates the flow pattern of the cooling liquid, and is reliable for the flow around the tube bundle. Currently used methods of heat exchanger heat calculation based on criterion dependencies do not take into account all characteristics of the flow.
Keywords: Boiler, reactor, heater, furnace, filter, air cooler, electrodehydrator, gasoline, diesel, catalyst, injector, pump, piping, hot flow, cold flow.

Introduction. In the chemical industry, the transfer of heat from one stream to another is an important operation. These devices used to ensure efficient heat transfer are called heat exchangers. You can also save energy by using heat exchangers.
All heat exchangers work in principle the same, but they do it in different ways. Heat exchange between surface devices is widely used devices made of surface tubes. There are two types of surface devices; Recuperative and regenerative. In recuperative devices, heat is transferred through a special heating surface, that is, through a wall that divides the flows. In regenerative devices, heat is transferred through the wall. However, these currents pass through that surface in sequence.

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Shell and tube heat exchangers are a class of heat exchangers. Heat exchangers are used to transfer heat from one medium to another. Performs heat exchange and other large chemical processes in oil refineries. Here, heat exchange takes place between two streams, hot and cold. The environment with a high temperature gives its heat to the environment with a low temperature, and as a result, the process of heat exchange occurs. As the name suggests, the main part of this type of heat exchanger consists of a body and a tube.

Here, at different starting temperatures, one of the flows moves inside the tubes, and the other moves between the tubes, that is, inside the body. In these heat exchangers, equipped with one or two pipe networks, it is possible to move the flows in the opposite or the same direction. To transfer heat efficiently, it must have a larger transfer area. Therefore, it is advisable to place more tubes in the apparatus. Thus, it becomes possible to use the wasted heat. This method is a good way to save energy. According to their construction, shell-and-tube heat exchangers are different and are as follows.

- fixed pipe network (T);
- with a temperature compensator in the body (K);
- floating head (F);
- U-shaped pipe (U);

Fixed tube heat exchangers. This type of apparatus is the simplest and cheapest type of heat exchanger. In these devices, both networks are welded to the body, and no relative movement of the network is possible. Pipes are connected to the pipe network by expansion.

The device is equipped with a detachable cover on both sides and a dispensing chamber on one side. It is possible to increase the number of flow channels by placing single and multiple longitudinal partitions in the distribution chamber.

If the temperature difference between the tubes and the body exceeds 300°C, this heat exchanger is unusable. This is due to the fact that the pipes and the extension of the body are not of the same size, and the value of the voltage generated in the network increases further, breaking the mode of the connection of the pipes in the network.

The diameter of the body and pipe should be such that it can provide the maximum heat transfer area. The flow rate between the pipes is also determined by the placement of the pipes in the pipe network. The distance between the inner surface of the body and the tube set should be small. If this is not followed, most of the heat carrier will not participate in the heat exchange process.

The main advantage of this device is its simple construction. Along with its advantages, it has a number of disadvantages. One of them is that the outer metal surface of the pipes cannot be mechanically cleaned. The fact that the construction of the device does not allow differential thermal expansion between the body and the pipe is also considered one of its disadvantages.

A heat exchanger with a compensator in the body. Thermal deformation in heat exchangers is characteristic not only for the internal elements of the device, but also for the body.

If the thermal stresses in the body of the heat exchanger or the walls of the pipes are large, then it is necessary to reduce it, even if relatively. For this reason, a lens-shaped compensator is added to the body of the heat exchanger.

Basically, the deformation of the body due to temperature is compensated by compression and expansion of the compensator in the axial direction. At high pressures, the thickness of the compensator wall is increased. The lenticular compensator is made by rolling cylindrical coatings. The compensation ability of this compensator corresponds to the number of lens elements located

in it. As the devices are hydraulically tested, drain holes are placed on the underside of the lens to drain fluid.

The heat exchanger with a lens compensator is used in cases of small thermal deformation, that is, no more than 13-15 mm. The compensator must have great flexibility, so it is thinner than the body of the apparatus.

Compensator construction is more flexible than thick-walled casing, although it is more susceptible to damage during service. For using low-potential heat, closed two-phase thermosyphon heat exchanger is considered superior to shell-and-tube heat exchangers.

U-shaped tube heat exchanger. Although flat-tube heat exchangers have many advantages, they cannot be widely used in some areas. Therefore, a heat exchanger with U-shaped tubes is used. The construction of a simple straight pipe is simple because the pipes do not need to be bent like U-shaped pipes. However, U-shaped pipes require a pipe network and the same number of caps. This significantly reduces costs.

Other flat tube heat exchangers may suffer internal damage due to thermal expansion. Placing a compensator on the body can alleviate this problem, but this additional compensator is not cheap. U-shaped pipes, on the other hand, are attached to a pipe network and allow the pipes to stretch freely without damage.

In the U-shaped device, the tube set can be easily removed from the body. This allows easy inspection and cleaning of pipes. The downside is that they cannot be cleaned mechanically. They supply water and steam inside the tube to perform the cleaning. In this type of heat exchanger, it is not possible to replace the central pipes in the tube set. U-shaped pipes are made by bending straight pipes. Another disadvantage is the complexity of the shape of the tubes and the difficulty of placing them in the body when the number is large.

In order to reduce the bending stresses caused by the masses of the pipes and the medium flowing through them for the convenience of installation and the connection of the pipes to the network, the pipe set of the horizontal U-type heat exchangers with a diameter of 800 mm and more are placed on roller supports.

U-shaped pipes are usually made by bending the pipe while it is cold or hot. In order to avoid significant wall thinning and folding on the stretched side of the steel tube, they adopt a bending radius of $R \geq 4dx$ (dx−outer diameter of the tube).

The significant disadvantages of the U-type device include the impossibility of replacing the tubes when they fail (except for the outer tubes), as well as the complexity of placing the tubes, especially when there are a large number of them. Due to the indicated shortcomings, heat exchangers of this type are not widely distributed.

Floating header shell-and-tube heat exchanger. Floating head devices are used when it is necessary to cool and heat gas or liquid mixtures without changing the aggregate state of the flow. The floating head heat exchanger has high productivity and wide application possibilities. Due to these features, it is widely used in the industry. In this type of heat exchanger, the tube network inside the body is not welded to the body and is allowed to float, that is, to move. The stationary pipe network is fixedly connected to the body. Using a floating head allows the tube set to expand due to heat. It is this head that moves with the expansion of the tubes. The floating head also allows the tubes to be removed from the body for cleaning. This floating head apparatus is suitable for severe processes with high pressure and temperature, and can be used in cases where the temperature is less than or equal to 452°C and the pressure is not more than 6.5 MPa.

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As an advantage, it can be noted that the tube set of the device can be easily removed from the body, inspected, repaired, replaced with a new one, and mechanically cleaned. To secure the cover of the floating head, it must be bolted to the pipe network. This prevents multiple pipes from being placed in the pipe network in the bolt circle.
Bodies with diameters D≤600 mm are mainly made of pipes, and those with larger diameters are made of rolled steel sheets. In the latter case, especially for the large length of the apparatus, the body can be made of three belts: the central one and the two ends.
Condensing elements in the construction of the apparatus also form restrictions on pressure and temperature. In the apparatus, the tubes expand as a group rather than individually as in U-shaped tubes. The fact that the floating head is complex due to its structure and it is impossible to control its movement during the operation process is considered as a missing aspect.

Oil primary processing (CDU/VDU). The primary processing of oil begins with its receipt at the CDU/VDU unit. This is far from the only and not the last installation necessary to obtain a quality product, but the efficiency of other links in the technological chain depends on the operation of this particular section. Installations for primary oil refining are the basis for the existence of all oil refineries in the world. It is in the conditions of primary distillation of oil that all components of motor fuel, lubricating oils, raw materials for the secondary refining process and petrochemistry are separated. Both the quantity and quality of fuel components, lubricating oils, technical and economic indicators, the knowledge of which is necessary for subsequent cleaning processes, depend on the operation of this unit. Device - automobile gasoline components (d.b.-85oC and 85-180oC fractions), jet fuel (140-240oC fraction), diesel fuel (240-360oC fraction), vacuum gas oil (360-520oC fraction), tar (over 520oC fraction), as well as working for obtaining hydrocarbon gas and liquefied gas "head".
The standard CDU/VDU installation consists of the following blocks:
electric desalination plant (ECP);
atmospheric;
vacuum;
stabilization;
distillation (secondary distillation);
alkalizing.
Each of the blocks is responsible for the selection of a certain faction.
Oil refining technology. In order to reduce the cost of oil refining due to the loss of light components and wear of processing equipment, all oil is subjected to pretreatment, the essence of which is the destruction of oil emulsions by mechanical, chemical or electrical methods. Each enterprise uses its own oil refining methodology, but the general template remains the same for all organizations involved in this field. The refining process is extremely laborious and time-consuming, and this is primarily due to the catastrophic decrease in the amount of light (refined) oil on the planet. It is difficult to process heavy oil, but new discoveries are made in this field every year, so the number of effective ways and methods of working with this product is increasing. Co-construction of hydrocracking and catalytic cracking units within deep oil refining complexes appears to be the most efficient for the production of high-octane gasolines and high-quality middle distillates.

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NEFTİN İLKİN EMALİ VƏ İSTİFADƏ OLUNAN İSTİLİKDƏYİŞDİRİCİ APARATLAR

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XÜLASƏ

Müasir neft emalı sahəsində müxtəlif texnoloji proseslər tətbiq olunur. Proseslərin hər biri öz növbəsində bir çox texnoloji sxem və üsullarla həyata keçirilir. Neft emalı və kimya istehsalında bu texnoloji proseslər bir çox sadə proseslərin əsasını təşkil edir. Bu yolla proseslərin öyrənilməsi asanlaşdırılır. Onlar neft və onun məhsullarını müxtəlif proseslər tətbiq etməklə emal edirlər.
Neft emalı və onun əsas üzvi sintez zavodları müxtəlif texnoloji proseslərin məcmusundan və ümumi təsərrüfatlarından ibarətdir. Zavodlardan qəbul edilən məhsulların sayından və keyfiyyətindən asılı olaraq texnika və avadanlıqlarla təmin olunmasına böyük diqqət yetirilir. Məhz bu avadanlıq və cihazlar vasitəsilə texnoloji proseslər həyata keçirilir. İstilik dəyişdiriciləri neft emalı sənayesində ən çox istifadə olunan aparatlarından biridir. İstilik dəyişdiricilərinin ən çox yayılmış növü gövdə borulu istilikdəyişdiriciləridir. Gövdə borulu istilik dəyişdiriciləri neft və qaz sənayesində xassələri yaxşılaşdırmaq və özlülüyünü azaltmaq üçün texnoloji olaraq geniş istifadə olunur.
Gövdə borulu istilik dəyişdiricisinin dizayn etibarlılığının paylanması və müxtəlif növ və versiyalara görə geniş temperatur, təzyiq və aşındırıcı mühitdə işləmək üçün istifadə olunur.
İstehsalın inkişafının hazırkı mərhələsində istifadə olunan texnoloji avadanlıqların səmərəliliyinin artırılması, istilik mübadilə avadanlığına münasibətdə yüksək enerji səmərəliliyinin təmin edilməsi mühüm tendensiyadır.
İstilik dəyişdiricisinin borulararası məkanında çarpaz cərəyanı təşkil etmək və soyutma sürətini artırmaq üçün müxtəlif konfiqurasiyalı kəsiklərdən istifadə olunur. Bu cür arakəsmələrin olması soyuducu mayenin axınının sxemini əhəmiyyətli dərəcədə çətinləşdirir və boru dəstəsi ətrafındakı axın üçün etibarlıdır. Hal-hazırda istifadə olunan istilik dəyişdiricisinin istilik hesablama üsulları kriteriyalardan asılı olaraq, axının bütün xüsusiyyətlərini nəzərə almır.
Açar sözlər: kalon, reaktor, istilikdəyişdirici, soba, filtr, hava soyducusu, elektrodehidrator, benzin, dizel, katalizator, injektor, nasos, boru dəsti, isti axın, soyuq axın.

АППАРАТЫ ПЕРВИЧНОЙ ПЕРЕРАБОТКИ НЕФТИ И ТЕПЛООБМЕННИКИ

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РЕЗЮМЕ

В области современной нефтепереработки применяются различные технологические процессы. Каждый из процессов в свою очередь реализуется множеством технологических схем и методов. Эти

технологические процессы лежат в основе многих простых процессов в нефтеперерабатывающих и химических производствах. Таким образом, облегчается процесс обучения. Они перерабатывают нефть и ее продукты, используя различные процессы.

Нефтепереработка и ее основные заводы органического синтеза состоят из комплекса различных технологических процессов и общих сооружений. В зависимости от количества и качества продукции, поступающей с заводов, большое внимание уделяется обеспечению машинами и оборудованием. Именно с помощью этого оборудования и устройств осуществляются технологические процессы. Теплообменники являются одним из наиболее широко используемых устройств в нефтеперерабатывающей промышленности. Наиболее распространенным типом теплообменников являются кожухотрубные теплообменники. Кожухотрубные теплообменники широко используются технологически в нефтегазовой отрасли для улучшения свойств и снижения вязкости.

Применяется для распределения конструктивной надежности кожухотрубного теплообменника и работы в широком диапазоне температур, давлений и агрессивных сред по разным типам и исполнениям.

Повышение эффективности технологического оборудования, используемого на современном этапе развития производства, обеспечение высокой энергоэффективности по отношению к теплообменному оборудованию является важным направлением.

Сечения различной конфигурации используются для организации поперечного тока в межтрубном пространстве теплообменника и увеличения скорости охлаждения. Наличие таких перегородок существенно усложняет схему движения теплоносителя и является надежным для обтекания пучка труб. Применяемые в настоящее время методы расчета тепла теплообменника в зависимости от критериев не учитывают всех характеристик потока.

Ключевые слова: котел, реактор, нагреватель, печь, фильтр, воздухоохладитель, электродегидратор, бензин, дизель, катализатор, инжектор, насос, трубопроводы, горячая подача, холодная подача.

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RESEARCH ON THE TECHNOLOGY OF PREPARING PLASTIC AND THREADED COMPONENTS USING 3D PRINTING OR ADDITIVE MANUFACTURING

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ABSTRACT

Threaded components play a crucial role in ensuring the safety and reliability of systems by joining components together. Proper selection of thread type and size, ensuring proper machining and storage of components, and addressing potential issues such as leakage, vibration, and misalignment all play a special role. It is known that there is a big difference in the nature of the destruction of metal and plastic threaded connections, in particular, when the nut is made of plastics, and the bolt is made of steel, or vice versa. In this regard, at present there is no consensus in assessing the strength of plastic threaded connections. On the one hand, it is recognized that, due to a more uniform distribution of the load, plastic threaded connections have a significant load capacity. Numerous examples of the use of plastic threaded connections in pressure pipelines, in large plastic parts subjected to dynamic loads, various loaded fasteners - all these examples confirm that plastic threaded connections can withstand very high loads. Production of a thread of plastic details is rather difficult, than on metals. It is connected with the physical-mechanical processes coming in the course of production of concrete thread details from plastic by method of pressing and casting under pressure. Also mechanics of formation of plastic threads on details of the oil-field equipment on the specific properties differ from the threads received by a machining method on metals. As thread surfaces on plastic details are formed in compression molds depending on materials and the modes: temperatures, pressure and time of production. These regime parameters and guided parameters play a part at a guaranty of physicalmechanical properties of details in the course of production. The use of plastic or polymer threads in the oil and gas industry is increasing due to their unique characteristics and advantages over traditional metal threads. Recently, 3D printing (additive manufacturing) has become more widely used for the preparation of plastic threads. The article will discuss the methods and characteristics of preparing plastic threaded components, as well as their advantages and certain incompatibilities.
Keywords: threaded components, plastic threaded components, preparation methods, 3D and 4D printing.

Introduction. The shapes of threads used in industry are often square, triangular, or trapezoidal in various threading systems. Thread combinations can be made from various materials, including stainless steel, brass, aluminum, and plastic. The choice of material depends on specific applications and requirements for strength, corrosion resistance, and temperature resistance [1].
Threaded parts are widely used in all sectors of industry, including conveyors, pumps, compressors, and many different types of machines and tools, including assembly equipment.

Threaded parts are also used in many different parts of the oil and gas industry, including drilling rigs, pipeline fittings, and oil storage tanks. The use of threads in this field is widespread due to their unique properties and advantages compared to traditional metal threads. Plastic threads have some advantages in the oil and gas industry. For example, plastic threads are resistant to various chemical substances and materials, including saltwater, pickles, and hydrocarbons. This makes them ideal for use in harsh environments where metal threads would be prone to corrosion. Plastic threads are also significantly lighter than metal threads. This can be useful in situations where weight is a critical factor, such as in offshore drilling operations.

Compared to metal threads, plastic threads have less friction, which can help reduce wear and extend the life of gear assemblies. Plastic threads are often cheaper than metal threads, which can be beneficial in situations where cost is a critical factor. These threads can be easily installed and removed without the need for specialized tools or equipment, unlike metal threads that require special tools and equipment such as torque wrenches [2].

Plastic threads are more agile and can move more freely than metal threads, which can be useful in situations where vibration or movement is a problem. Unlike metal threads, plastic threads have a higher temperature resistance, which can be useful in situations where high temperatures are a concern.

Purpose of the study. There are several methods for producing plastic parts with grooves in modern industry (figure 1) [3,4];

- Injection molding involves using a mold to inject molten plastic and then removing the cooled part from the mold;
- Fused Deposition Modeling (FDM) 3D printing technology uses a heated filament of thermoplastic material to create a layered object
- Stereolithography (SLA) 3D printing technology uses a UV laser to create a layered resin coating. SLA is capable of producing high-resolution and intricate parts, but it is relatively expensive and limited in material selection;

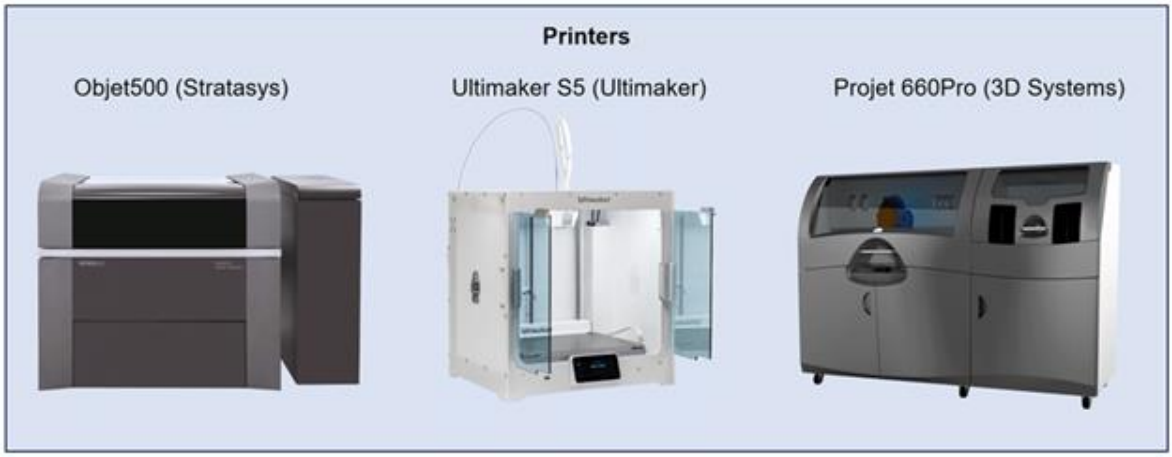

Figure 1: 3D printing printer models.

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- Laminated Object Manufacturing (LOM) technology uses a laser to cut paper, plastic, or metal layers to create a component;
- Cold forming involves using compression force at room temperature to shape a plastic part. Cold forming is used to create grooves on rollers or hexagonal shafts.

Methodical base of the study. 3D printing, also known as additive manufacturing, is a process that uses a digital model to create a physical object by sequentially layering the material. Instead of carving or machining the object out of a larger piece of material, it is built up layer by layer. 3D printing is used to create a wide variety of parts, including those with complex shapes and features such as threaded components (figure 2) [5].

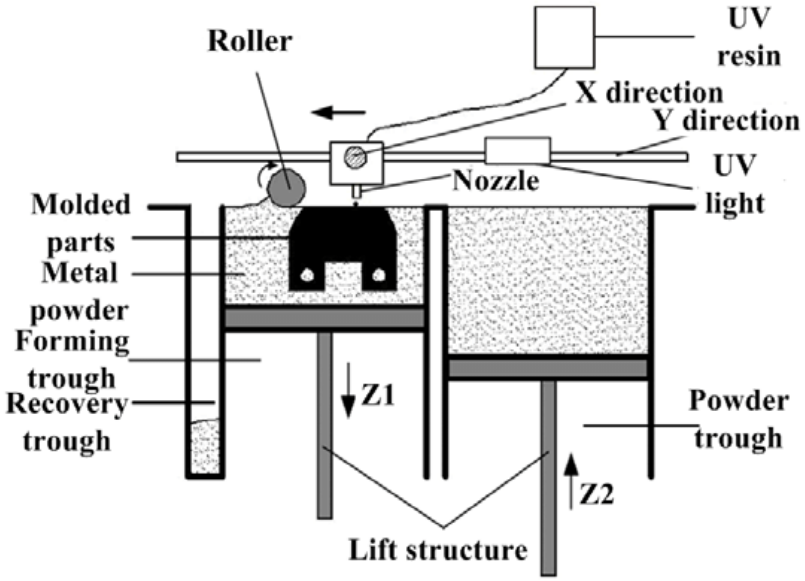

Figure 2: Schematic of the 3D printing process.

On the other hand, 4D printing is a term used to describe the use of 3D printing to create objects that can change their shape or function over time. This is achieved by using materials that respond to external stimuli such as temperature, humidity, or mechanical force. In this context, the fourth dimension is time. An example of a 4D-printed component is a threaded part that can change its shape to adapt to different loads or conditions.

The first step in preparing threaded parts using 3D or 4D printing is to design the part using computer-aided design (CAD) software. The design must take into account the material properties that will be used for printing, as well as the desired final shape and function of the part. Once the design is completed, it is loaded onto a 3D printer that reads the design and builds up the part layer by layer.

3D printing offers several advantages compared to traditional manufacturing methods such as injection molding and casting. Some of the key benefits of 3D printing include:

Design flexibility: 3D printing enables the creation of complex geometries and internal structures that may be difficult or impossible to produce using traditional manufacturing methods.

Rapid prototyping: 3D printing can produce a physical prototype of a design within a matter of hours, allowing for faster product development and iteration.

Low-volume production: 3D printing is ideal for low-volume production runs, as it does not require significant tooling costs associated with traditional manufacturing methods.

Despite these advantages, the use of plastic and polymer materials in the oil and gas industry may have certain limitations. For example, they may not be as strong as metal materials and may not be able to withstand high loads and pressures. Additionally, they may not be suitable for use in situations where cold temperatures are a concern [6,7].

Discussion of the obtained results. The development of new technologies for the oil and gas industry has always been challenging, especially when it involves the production and processing of new materials. Although the application of 3D printing in the industry is still in its early stages, its potential benefits are noteworthy. The peculiarities of the global oil and gas market in the coming decades suggest that the need for additional production in the industry is simply to reduce its production costs, as 3D printing allows for the production of materials in their precise form with minimal or no waste. Most importantly, the adoption of 3D printing could move the oil and gas industry towards on-demand and practical production of required spare parts.

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PLASTIK YİVLİ HISSƏLƏRİN 3D ÇAP VƏ YA ƏLAVƏ İSTEHSAL ÜSULU İLƏ HAZIRLANMA TEXNOLOGİYASININ TƏDQİQİ

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XÜLASƏ

Yivli hissələr komponentləri bir-birinə birləşdirmək, istifadə etdikləri sistemlərin təhlükəsizliyini və etibarlılığını təmin edir. Düzgün yiv növü və ölçüsünü düzgün seçmək, hissələrin lazımi şəkildə bərkidilməsini və saxlanmasını təmin etmək, sızma, vibrasiya və nasazlıq kimi potensial problemlərin qarşısını almaqda xüsusi rol oynayır. Məlumdur ki, metal və plastik yivli hissə birləşmələrinin dağılma xüsusiyyətləri böyük fərq kəsb edir. Bu əsasən qaykanın plastik kütlədən, bolt isə poladdan və ya əksinə olan hallarda özünü göstərir. Bununla əlaqədar olaraq hal-hazırda plastik yivli birləşmələrin qiymətləndirilməsində müxtəlif fikir formalaşır. Belə ki, plastik yivli birləşmələrdə yükləmənin bərabər paylanması üstünlüyü vardır. Buna misal olaraq, basqılı boru kəmərlərinin, yüksək dinamik yükləməyə məruz qalan böyük plastik detalların, müxtəlif yüklü bərkidici detalların plastik yivli birləşmələrini göstərmək olar. Bu misallar plastik yivli birləşmələrin istənilən böyük yükləmələrə davamlı olmasını göstərir. Plastik yivli detalların hazırlanması metal yivlərə nisbətən mürəkkəbdir. Bu plastik yivlərin presləmə və təzyiqlə tökmə üsulları ilə hazırlanmasında fiziki-mexaniki proseslərdən asılıdır. Belə ki, plastik detalların yiv səthləri press qəlib materialdan və rejim parametrlərindən (temperatur, təzyiq və hazırlanma vaxtından) asılı olaraq formalaşır. Hazırlanma prosesində rejim və idarəetmə parametrləri detalların fiziki-mexaniki tərkibinin təmin olunması üçün üstünlük təşkil edir. Neft və qaz sənayesində plastik yivlərin istifadəsi ənənəvi metal yivlərə nisbətən unikal xüsusiyyətləri və üstünlükləri səbəbindən getdikcə artır. Son zamanlarda plastik yivlərin hazırlanması üçün digər üsullara nisbətən daha geniş yayılmış 3D çap (əlavə istehsal) metodundan istifadə olunur. Məqalədə plastik yivli hissələrin hazırlanma üsulları və xüsusiyyətləri, eləcə də onların üstünlükləri və müəyyən çatışmazlıqlarından bəhs edilir.
Açar sözlər: yivli hissələr, plastik yivli komponentlər, hazırlanma üsulları, 3D və 4D çap.

ИССЛЕДОВАНИЕ ТЕХНОЛОГИИ ИЗГОТОВЛЕНИЯ ПЛАСТМАССОВЫХ РЕЗЬБОВЫХ ДЕТАЛЕЙ С ИСПОЛЬЗОВАНИЕМ МЕТОДА 3D ПЕЧАТИ ИЛИ ДОПОЛНИТЕЛЬНОГО ПРОИЗВОДСТВА

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РЕЗЮМЕ

Резьбовые соединения играют решающую роль в обеспечении безопасности и надежности систем, соединяя компоненты вместе. Особое значение имеет правильный выбор типа и размера резьбы, обеспечение надлежащей обработки и хранения компонентов, а также решение потенциальных проблем, таких как утечка, вибрация и смещение. Известно, что существует большое различие в характере разрушения металлических и пластмассовых резьбовых соединений, в частности, когда гайка изготовлена из пластмасс, а болт-стальной или наоборот. В связи с этим в настоящее время не существует единого мнения в оценке прочности пластмассовых резьбовых соединений. За счет более равномерного

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распределения нагрузки пластмассовые резьбовые соединения обладают значительной нагрузочной способностью. Многочисленные примеры использования пластмассовых резьбовых соединений в напорных трубопроводах, в крупных пластмассовых деталях, находящихся под действием динамических нагрузок, различные нагруженные крепежные детали – все эти примеры подтверждают, что пластмассовые резьбовые соединения могут выдерживать весьма большие нагрузки. Изготовление резьбы пластмассовых деталей сравнительно сложно, чем на металлах. Это связано с физико-механическими процессами, происходящими в процессе изготовления конкретных резьбовых деталей из пластмасс методом прессования и литья под давлением. Также механика формирования пластмассовых резьб на деталях нефтепромыслового оборудования по своим специфическим свойствам отличаются от резьб полученных методом механической обработки на металлах. Так как резьбовые поверхности на пластмассовых деталях формируются в пресс-формах в зависимости от материалов и режимов: температуры, давления и времени изготовления. Эти режимные и управляемые параметры играют определенную роль при обеспечивании физико-механических свойств деталей в процессе изготовления. Использование пластиковых соединений в нефтегазовой промышленности расширяется благодаря их уникальным характеристикам и преимуществам по сравнению с традиционными металлическими резьбами. В последнее время 3D-печать (дополнительное производство) стала более широко применяться для изготовления пластиковых соединений. В статье будут рассмотрены способы и особенности изготовления пластиковых резьбовых деталей, а также их преимущества и некоторые несовместимости.
Ключевые слова: резьбовые детали, пластиковые резьбовые детали, способы изготовления, 3D и 4D печать.

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METHODOLOGY OF OBTAINING CHROMIUM CARBONYL COMPLEXES AND DEVICES USED IN OBTAINING THEM

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ABSTRACT

The development of modern technology and the long-term processing of materials and constructions used in high temperature conditions make great demands. It is very important to obtain hard-melting metals that meet these requirements. In nature, the scarcity of hard-to-melt metals and their high cost force us to find other more efficient ways. One such solution is the application of hard- -melt metals in the form of thin layers or coatings on metals or structures. For to this purpose, carbonyl compounds of hard-to-melt metals are widely used in technology recently. Carbonyl compounds have important properties, one of which is that they act as raw materials for obtaining coatings and layers through thermal decomposition. However, some difficulties arise in obtaining chromium coatings based on chromium carbonyl complexes with organic ligands. In order to overcome such difficulties, the synthesis methodology of two chromium-based complex compounds with easy volatility and low decomposition temperature, which are used in the production of corrosion-resistant coatings, and the temperature range in their decomposition limits, physical chemical structure parameters have been determined. The research found that both chromium carbonyl complexes obtained by synthesis form chromium coatings with high adhesion on the metal carrier and increase their corrosion resistance. Chromium carbonyl complexes can serve as technologically favorable raw materials for obtaining the necessary chromium coating during the decomposition of CO groups at a very low temperature range (100-150 C) without creating additional pressure. Both synthesized complex compounds are raw materials for obtaining corrosion-resistant coatings on weld seams of 09Г2С steel. The use of these complexes as active fillers in abrasive metallurgy has also been determined.

Keywords: Chromium, solvent, toluene, mesethylene, infrared spectrum, chromium carbonyl, complex, melting, decomposition, coating, heating, solution.

Introduction: The development of modern technology and the long-term processing of materials and constructions used in high temperature conditions make great demands. It is very important to obtain hard-melting metals that meet these requirements. In nature, the scarcity of hard-to-melt metals and their high cost force us to find other more efficient ways. One such solution is the application of hard-to-melt metals in the form of thin layers or coatings on metals or structures. For this purpose, carbonyl compounds of hard-to-melt metals are widely used in technology recently. Carbonyl compounds have important properties, one of which is that they act as raw materials for obtaining coatings and layers through thermal decomposition. However, some difficulties arise in obtaining chromium coatings based on chromium carbonyl complexes with organic ligands.

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In order to overcome such difficulties, the synthesis methodology of two chromium-based complex compounds with easy volatility and low decomposition temperature, which are used in the production of corrosion-resistant coatings, and the temperature range in their decomposition limits, physical chemical structure parameters have been determined.

Research Methodology:

1. Synthesis method of tolylchrometricarbonyl-$C_6H_5(CH)_3Cr(CO)_3$ complex: 1 mmol of hexachromocarbonyl – $Cr(CO)_6$, with a melting point of 120 degrees and different frequencies in the IR spectrum, in 50 ml of toluene with a reflux cooler and mixer In a 3-necked 250 ml flask, it is boiled until some of the hexachrome carbonyl groups are replaced by toluene molecules. It is boiled for about 7-8 hours. After the reaction is over, the mixture obtained is studied by the IR-spectral method. The temperature of the solution is cooled to room temperature. we separate the mixture from toluene under vacuum. 1.36 grams of tolylchrometricarbonyl $C_6H_5(CH)_3Cr(CO)_3$ complex of yellow color with a high degree of purity is obtained from the mixture by sublimation by heating it to 30-40 degrees. The complex $Cr(CO)$ According to 3, the yield is 87.8%. It also has a melting point of 91-92 degrees and a decomposition temperature of 92-108 degrees.

Microanalysis results: in %, C - 52.6, H - 3.5, Cr - 22.8.

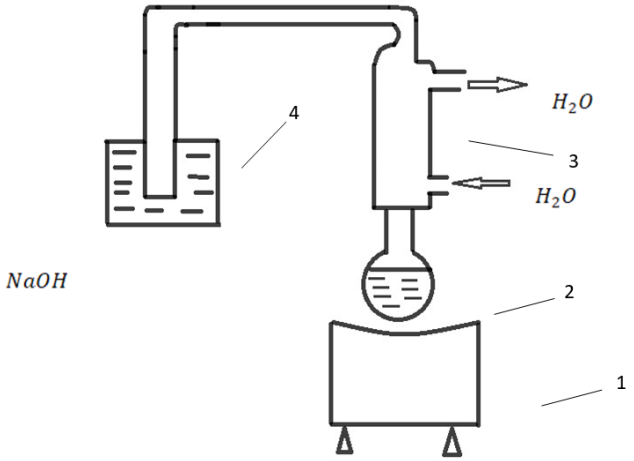

Figure 1: Unit for the synthesis of $C_6H_5(CH_3)Cr(CO)_3$ and $C_6H_3(CH_3)Cr(CO)_3$ complexes: 1– electric stove; 2 – three-necked flask; 3 - counter cooler; 4 - absorbent bowl.

Research object: П-$CH_3C_6H_5CR(CO)_3$ CONTAINING 52.02% C, 3.48% H, 22.70% CR, П CONTAINING 55.88% C, 4.57% H, 20.30% CR -(CH3)3 C6H3CR(CO)3 complexes and 09Г2С steel to be coated are taken as a basis.

2. Synthesis method of mesethylenechromiumtricarbonyl - $C_6H_3(CH_3)Cr(CO)_3$ complex: 1mmol (0.16 g) $Cr(CO)_6$ - is boiled with 100 ml of acetonitrite for 6-7 hours with counter-cooling in the vessel of method 1 .At this time, $Cr(CO)_6$ - three CO groups should be replaced by 3 $(CH)_3CN$ molecule. The reaction control is carried out by the IR spectral method. After that, the reaction 3 mol (2.7 ml) of toluene, $C_6H_5(CH)_3$ is added. The reaction mixture is boiled for half an hour and cooled to room temperature. Then all the solvents are removed by boiling. The necessary product

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is sublimated to separate it from the residue. $Cr(CO)_6$ is 92%. The complex composition has a melting temperature of 67-71 degrees and a decomposition temperature of 71-83 degrees.
The results of microanalysis were calculated: in %, C - 56.25, H - 4.69, Cr - 20.3.
As a result: C - 55.88. H - 4.57. Cr - 20.3%.
Another chromium carbonyl complex is the benzenechromiumtricarbonyl complex obtained by the reaction of hexacarbonylchromium with benzene.
The main method of $C_6H_6\ Cr(CO)_3$ synthesis can be obtained by replacing the CO group with the $Cr(CO)_6$ group, as in other benzoid arenemetaltricarbonyl.

$$Cr(CO)_6 + C_6H_6 \longrightarrow C_6H_6\ Cr(CO)_3 + 3CO$$

This reaction was synthesized by three different researchers (Fischer, Nutt and Nicholson). But their reaction conditions are different. Fischer replaced the CO group by heating the mixture of chromium hexacarbonyls with arene at 235 degrees in a closed system.

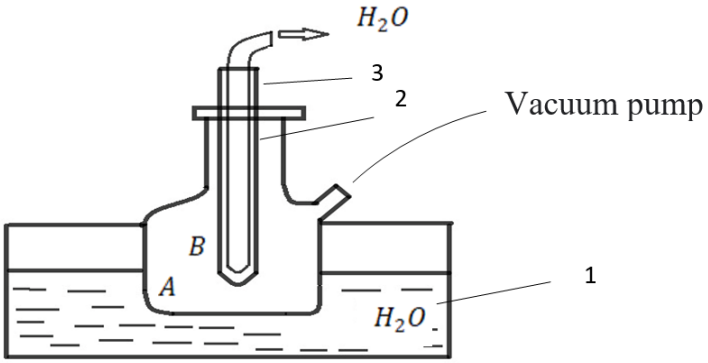

Figure 2: Apparatus for sublimation of C6H5CH3Cr(CO)3 and C6H3(CH3)Cr(CO)3 complexes. 1 – water container; 2 – sublimation vessel; 3 – water-cooled cartridge cooler; A – substance to be sublimated; B – sublimated substance.

The yield of $C_6H_6\ Cr(CO)_3$ from $Cr(CO)_6$ is 30%. Natta applied the synthesis at a relatively low temperature (210-223). According to them, $C_6H_6\ Cr(CO)_3$'s output is 80%.
Nicholson conducted the synthesis of $Cr(CO)_3$ in an open system by applying countercooling. To obtain the required temperature, they used solutions with a high boiling point.
According to studies, the yield of $C_6H_6\ Cr(CO)_3$ is 30 percent.
C_6H_6 can be obtained by taking $Cr(CO)_3$ at a temperature lower than the decomposition temperature of $Cr(CO)_3$.
The synthesis of $C_6H_6\ Cr(CO)_3$ can be obtained by replacing the CO group with $Cr(CO)_6$ and mainly with the C_6H_6 group, as in other benzoic arenemetaltricarbonyl.

$$Cr(CO)_6 + C_6H_6 \longrightarrow C_6H_6\ Cr(CO)_3 + 3CO$$

The evaporator sublimates $Cr(CO)_6$ in the lower part of the refrigerator. The solvent is filtered again with the reaction mixture with benzene mixture. In order to dissolve $Cr(CO)_6$ well, the solvent is heated to 60 degrees with boiling water in the refrigerator, then to 78 degrees. In this

case, $Cr(CO)_6$ is completely filtered into the reaction vessel. The temperature in the system is kept at 165 degrees and cooled in cold water in the refrigerator .

3 grams of $Cr(CO)_6$ are placed in 20 ml of dimethylglyoxime (diglime) and 20 ml of C_6H_6 in a reaction vessel. The reaction mixture is heated to 160 degrees, and at this time, cold water is added to the cooler, then hot water is added to the cooler at 160 degrees. For 14 hours, CO is separated, then the solvent is removed under vacuum conditions at 70 degrees. Then the solution is passed through a filter and cooled to 10 degrees. 2.82 grams of yellow substance with a melting temperature of 166.5 degrees is precipitated. The yield according to $C_6H_6\ Cr(CO)_6$ is 97%. By sublimating the finished product in a high vacuum at 90 degrees, they separate 4.7 grams of 93% $C_6H_6\ Cr(CO)_3$.

Results and Discussion.

1. Some physical and chemical thermostabilities of the synthesized complexes were studied. It is known that either $(CH)_3C_6H_5Cr(CO)_3$ or $(CH)_3C_6H_3Cr(CO)_3$ complex does not sublimate at the absolute melting temperature. showing the property, they decompose very easily in the gas phase.
2. The method of synthesis of two new organic ligand chromium carbonyl complexes - tolylchromiumcarbonyl and mesethylchromiumcarbonyl - which are used in the production of chrome coatings by the corrosion-resistant carbonyl method, has been developed.

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XROMKARBONİL KOMPLEKSLƏRİNİN ALINMASININ METODİKASI VƏ ALINMADA İSTİFADƏ EDİLƏN QURĞULAR

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XÜLASƏ

Müasir texnologiyanın inkişafı və yüksək temperatur şəraitində istifadə edilən material və konstruksiyaların uzun müddət işlənməsi üçün böyük tələblər irəli sürülür. Bu tələblərə cavab verən çətin əriyən metalların alınması çox vacibdir. Təbiətdə isə çətin əriyən metalların azlığı və onların çox baha olması daha səmərəli başqa çıxış yolları tapmağa bizi vadar edir. Belə həll yollarından biri metal və ya konstruksiyaların üzərinə çətin əriyən metalların nazik təbəqə və ya örtük şəklində çəkilməsidir. Bu məqsədlə isə son zamanlar texnologiyada çətin əriyən metalların karbonil birləşmələrindən geniş istifadə olunur. Karbonil birləşmələr mühüm xassələrə malikdir ki, biri də onların termiki parçalanma yolu ilə örtük və təbəqələrin alınmasında xammal rolu oynamasıdır. Lakin üzvi liqandlı xrom karbonil komplekslərinin əsasında xrom örtüklərin alınmasında bəzi çətinliklər yaranır. Belə çətinlikləri aradan qaldırmaq üçün korroziyayadavamlı örtüklərin alınmasında işlənən asan uçuculuğa və aşağı parçalanma temperaturuna malik xrom əsaslı iki kompleks birləşmələnin sintez metodikası və onların parçalanma hüdudlarındakı temperatur intervalı, fiziki kimyəvi struktur parametrləri müəyyən edilib. Tədqiqatla müəyyən olunub ki, sintezlə alınan hər iki xrom karbonil kompleksləri metal daşıyıcı üzərində yüksək adgeziyaya malik xrom örtükləri əmələ gətirərək onların korroziyaya qarşı müqavimətin artırır. Çox aşağı temperatur aralığında (100-150 C) CO qruplarının əlavə təzyiq yaratmadan parçalanması zamanı lazımi xrom örtüyünün alınması üçün xrom karbonil kompleksləri texnoloji cəhətdən əlverişli xammal rolun oynaya bilər. Sintez edilən hər iki kompleks birləşmə 09Г2С marka poladın qaynaq tikişləri üstündə korroziyayadavamlı örtüklərin alınması üçün xammal olur. Həmçinin bu komplekslərin ovuntu metallurgiyasında aktiv doldurucu kimi istifadəsi də müəyyən olunub.
Açar sözlər: Xrom, həlledici, toluol, mezetilen, infraqırmızı spektr, xromkarbonil, kompleks, ərimə, parçalanma, örtük, qızdırılma, məhlul.

МЕТОДИКА ПОЛУЧЕНИЯ КАРБОНИЛЬНЫХ КОМПЛЕКСОВ ХРОМА И УСТРОЙСТВА, ПРИМЕНЯЕМЫЕ ПРИ ИХ ПОЛУЧЕНИИ

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РЕЗЮМЕ

Развитие современных технологий и многолетняя обработка материалов и конструкций, эксплуатируемых в условиях высоких температур, предъявляют высокие требования. Очень важно получить тугоплавкие металлы, отвечающие этим требованиям. В природе редкость трудноплавких металлов и их высокая стоимость вынуждают искать другие, более эффективные способы. Одним из таких решений является нанесение трудноплавких металлов в виде тонких слоев или покрытий на металлы или конструкции. С этой целью в технике в последнее время широко используются карбонильные соединения трудноплавких металлов. Карбонильные соединения обладают важными свойствами,

одним из которых является то, что они служат сырьем для получения покрытий и слоев путем термического разложения.Однако при получении хромовых покрытий на основе карбонильных комплексов хрома с органическими лигандами возникают определенные трудности.Для преодоления таких трудностей предложена методика синтеза двух комплексных соединений на основе хрома с легкой летучестью и низкой температурой разложения, которые используются при получении антикоррозионных покрытий, и температурный интервал их пределов разложения, параметры физико-химического строения. были определены.В результате исследований установлено, что оба карбонильных комплекса хрома, полученные синтезом, образуют хромовые покрытия с высокой адгезией на металлическом носителе и повышают их коррозионную стойкость.Карбонильные комплексы хрома могут служить технологически выгодным сырьем для получения необходимого хромового покрытия при разложении CO-групп в очень низкотемпературном интервале без создания дополнительного давления. Оба синтезированных комплексных соединения являются сырьем для получения антикоррозионных покрытий на сварных швах стали 09Г2С.Также определено использование этих комплексов в качестве активных наполнителей в абразивной металлургии.

Ключевые слова: хром, растворитель, толуол, меэтилен, инфракрасный спектр, карбонил хрома, комплекс, плавление, разложение, покрытие, нагревание, раствор.

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THE PROCESS OF RESTORING THE IMPELLER OF A CENTRIFUGAL PUMP IN A LASER INSTALLATION

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ABSTRACT

One of the widely used pumps in the oil industry is the centrifugal pump. During the long-term operation of the centrifugal pump, many failures are observed. One of the main failed parts is the impeller. As we know, an integral part of the functionality of a centrifugal pump is its impeller. Without an impeller, no centrifugal force can be generated on the incoming fluid. So, without an impeller, a centrifugal pump cannot work at all. For this reason, failure of the pump impeller had to be eliminated in order to prevent the pump from malfunctioning and to ensure the maximum length of uninterrupted operation of the pump. The main causes of impeller failure are the effects of cavitation, corrosion and erosion. Here, the coating (layer) resistant to corrosion and corrosion on the surfaces of the impeller of the centrifugal pump was considered. Specially for this, in the appropriate LD-2000 laser device, abrasives with different compositions were selected and their technological regime was developed. Ni, Cr, Fe, Si, Mo elements were used as abrasives. Knowing the composition and physical-chemical characteristics of each of these elements, an accurate report of the technological regime was conducted.
With this technological regime, it is appropriate to apply a coating (layer) of any thickness to the surface of the working wheels. This process was carried out in the laser center of the Azerbaijan State Oil and Industry University.
Keywords: alloy coating, abrasion, corrosion and corrosion resistance, technological mode, laser device.

Relevance of the topic

Central escape pump is widely used in oil and other industries to transport both cold and hot water, high viscosity and corrosive liquids, mixture of water with soot, peat, sediment and solid particles. These pumps are a device that transports fluid into the impellers of the working wheel due to the force of escape from the center with the help of pressure and pressure.
These pumps fail after long-term operation with the formation of micro-macro cracks with gradual hydroabrasive eating of the working wheel itself and its batteries.[1]
When these working wheels are sent for repair, 40-60% of them are completely useless and fail.Of these, it is possible to restore and reuse the remaining working wheels due to their wear limit and constructive parameters.Depending on the material and construction of the working wheel, it is required to develop a technology for restoring surfaces with a feed depth of 1.0-1.5

mm. Choosing modern restoration technology and its equipment, as well as auxiliary means, it was set to obtain a high-quality coating(sheet).

Setting the issue

The choice of the method of recovery technology, depending on the operating conditions, constructive parameters and operating mode of the center escape pump, is one of the most important issues. Various coatings of the methods carried out by scientists in the environment of vibration, metallization, plasma, flyus, carbon dioxide are not able to fully provide the required level of efficiency, reliability and longevity[2].

Taking into account these defects, it was proposed to apply a coating(layer) of various compositions on the surfaces of the working wheel with modern laser technology, which is more suitable for the purpose. To perform this process, the laser installation of the LD-2000 brand reflects the task of designing and selecting a solution of different composition depending on the material of the working wheel and processing the technological mode.

Theoretical research

Since the impulse of a solid-state laser lasts in small milliseconds, due to the short duration of the impulse from the small output power, it is possible to receive light with high power. Currently, they are working to further increase the power of solid lasers and to develop a technological mode for applying various coatings to the surface of the details. The sequence of this technological rejmin should be performed as follows[1,3].

1. 1. For solid-state implus laser, they determine its energy

$$E_L = P_L \cdot t_L \qquad (1)$$

Where: energy of EL-laser, Wattsan (Ws)

P_L laser power, Watts

t_L -the duration of the laser pulse, san.

2.The Fox Point depends on the geometric dimensions of the minimal lens, as well as the diameter of the beam and the length of light corresponding to it.Minimal focusing distance, mainly from diameter i.e., the smaller the diameter, the greater the power(power density) of the laser can be increased.

The power density of the laser is determined.

$$J = \frac{PL}{F} \text{ ore } J = \frac{E_L}{t_L \cdot F} \qquad (2)$$

J - power density or intensity, Watt/cm^2

The area of the F-beam can be defined as the area of the small diameter circle.

$$F = \frac{\pi d^2}{4}$$

Obtained results and their discussion

With the theoretical study of the technological regime, an accurate report can be made knowing the composition of the scrub and their physico-chemical characteristics.

In Table 1 below, the composition of the scrub and their characteristic are given.

Thermal properties of the composition of the scrub.

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With the theoretical study of the technological regime, an accurate report can be made knowing the composition of the scrub and their physico-chemical characteristics.
In Table 1 below, the composition of the scrub and their characteristic are given.

Table 1: Thermal properties of the composition of the scrub

Settings \ Elements	Ni	Cr	Fe	Si	Mo
Density, ρ q/sm^3	8907	7190	7500	5107	10220
Heat capacity (C), Kkal/m·K	143,6	116	640,57	1450	244
Coefficient of thermal conductivity (λ)	90,4	93,7	92	150	135
Amount of elements, (P)	63	15	7	0,08	17

According to the amount of the composition of the scrubbers in Table 1, the technological rejm is calculated with the following parameters.
1. The thermal conductivity coefficients of the elements are calculated. According to the amount of the composition of the scrubbers in Table 1, the technological rejm is calculated with the following parameters.

1. The thermal conductivity coefficients of the elements are calculated.

$$a_1 = \frac{\lambda_1}{c_1 \cdot \rho_1} = \frac{90,4}{143,6 \cdot 8907} = 70,67 \text{ mm}^2\text{/s-for nickel element;}$$

$$a_2 = \frac{\lambda_2}{c_2 \cdot \rho_2} = \frac{93,7}{116 \cdot 7190} = 112,34 \text{ mm}^2\text{/s-for xrom element;}$$

$$a_3 = \frac{\lambda_3}{c_3 \cdot \rho_3} = \frac{92}{640,57 \cdot 7500} = 19,14 \text{ mm}^2\text{/s-for ferrum element;}$$

$$a_4 = \frac{\lambda_4}{c_4 \cdot \rho_4} = \frac{150}{1450 \cdot 5170} = 20 \text{ mm}^2\text{/s-for silica element;}$$

$$a_5 = \frac{\lambda_5}{c_5 \cdot \rho_5} = \frac{135}{244 \cdot 10220} = 70,67 \text{ mm}^2\text{/s-for molybdenum element.}$$

According to the composition of these scrubbers, the production of coatings of different thicknesses on the surface of the working wheel in a semiconductor solid active substance laser installation can be carried out on the basis of the following parameters, i.e. according to the passport indicators of the laser installation.

$E = 1000Vt$ –power; d=3,0 mm-diameter of the light flood;

$f = 200\ mm$ – fox distance of laser;

$\lambda = 900 - 1050$ – light wave length.

2. Let's set the technological regime for the working wheel with different Steel materials

Table 2: Steel materials

Material	S_1 mm	S_2 mm	S_3 mm	S_4 mm	S_5 mm	T s.
Steel 40	0,5	1,0	1,5	2,0	2,5	0.88
Steel 40X	0,4	0,60	0,80	1,0	1,2	0,55
Steel 20X	1,0	1,2	1,4	1,6	1,8	3,26

Based on the research, a graphical dependence of the duration of the impulse for different elements of the thickness of the coating is established.

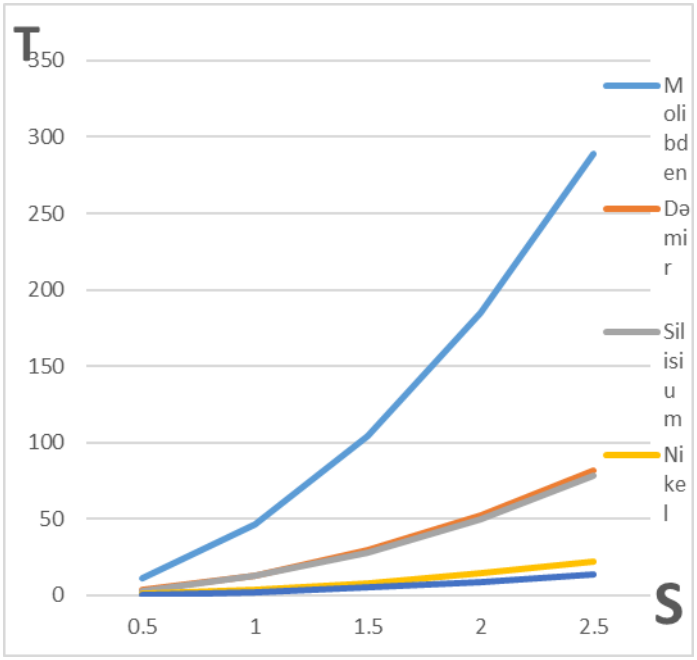

Figure 1: Graphic dependence of the duration of the impulse for different elements of the thickness of the coating.

Brief characterization of the laser installation. The Laser Center of Azerbaijan state oil and Industry University was opened on 16.06.2017 as part of the II startup and Innovation Festival of ASOIU. With laser heads in this laser installation, it is possible to increase the recovery technology and durability of the damaged parts of oil and gas mining equipment [3]. The laser is a light amplifier, and the light oscillator (generator) is obtained by directing the received laser beam back to the active medium. Here, the resonator is a gas discharge tube combined with flat mirrors with high reflectivity. Mirrors are placed exactly parallel on one axis opposite each other. The stopped wave reflected between the mirrors of the rezenator amplifies itself by continuous reflection. One of both mirrors is relatively transparent. By increasing the dimensions of the active element of the laser, its power can be increased [3,4].

Scope of application

The semiconductor laser installation has a high level of detail recovery technology and strength enhancement. The application in all areas of industry, including oil and gas mining equipment, the agrarian sector, the light and household technology industry, the petrochemical industry, which is more of an active chemical environment, can be considered suitable for the purpose. In this installation, it is possible to increase the durability several times by restoring the details, increasing the rigidity and strength of the coating layer and thermal processing. Depending on the operating conditions, it is possible to carry out technological processes in accordance with modern requirements by increasing the strength and durability of the restoration technology of the details.
Conclusion. The existing methods of increasing the resistance of the working wheel to corrosion and wear have been analyzed and the technological mode for obtaining a layer with ovate coatings on a modern laser installation has been developed. With this mode, it is possible to repeatedly increase the strength, corrosion and wear resistance by applying a scrubbed coating on the surfaces of any details.

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LAZER QURĞUSUNDA MƏRKƏZDƏN QAÇMA NASOSUNUN İŞÇİ ÇARXININ BƏRPA PROSESİ

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XÜLASƏ

Neft sənayesində geniş tətbiq edilən nasoslardan biri də mərkəzdən qaçma nasosudur. Mərkəzdən qaçma nasosunun uzun müddətli istismarı zamanı bir çox sıradan çıxma halları müşahidə edilir. Əsas sıradan çıxan hissələrdən biridə işçi çarxdır. Bildiyimiz kimi mərkəzdən qaçma nasosunun funksionallığının ayrılmaz hissəsi onun işçi çarxıdır. İşçi çarx olmadan daxil olan maye üzərində mərkəzdənqaçma qüvvəsi yarana bilməz. Beləliklə, işçi çarx olmadan mərkəzdənqaçma nasosu heç bir şəkildə işləyə bilməz. Bu səbəbdən, nasosun işləməməsinin qarşısını almaq və nasosun fasiləsiz işləməsinin maksimum uzunluğunu təmin etmək üçün nasosun işçi çarxında baş verən sıradan çıxma halları aradan qaldırılmalıdı. İşçi çarxın əsas sıradan çıxma səbəbləri kavitasiya, korroziya və yeyilmənin təsiridir. Burada mərkəzdən qaçma

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nasosunun işçi çarxının səthlərində korroziyaya və yeyilməyə davamlı örtüyün(təbəqənin) çəkilməsinə baxılmışdır. Bunun üçün xüsusi olaraq müvafiq LD-2000 lazer qurğusunda müxtəlif tərkibli ovuntular seçilərək onların texnoloji rejmi işlənib hazırlanmışdır. Ovuntu kimi Ni, Cr, Fe, Si, Mo elementlərindən istifade edilmişdir. Bu elementlərin hər birinin tərkibi və fiziki-kimyəvi xarakteristikasını bilərək texnoloji rejimin dəqiq hesabatı aparılmışdır.
Bu texnoloji rejimlə işçi çarxların səthinə istənilən qalınlıqda örtük(təbəqə) çəkilməklə tətbiq edilməsi uyğundur. Bu proses Azərbaycan Dövlət Neft və Sənaye Universtetinin lazer mərkəzində həyata keçirilmişdir.
Açar sözlər: Ərinti örtüyü, ovuntular, korroziyaya və yeyilməyə davamlılıq texnoloji rejm, lazer qurğusu.

ПРОЦЕСС РЕМОНТА КОЛЕСА ЦЕНТРОБЕЖНОГО НАСОСА В ЛАЗЕРНОЙ УСТАНОВКЕ

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РЕЗЮМЕ

Одним из широко используемых насосов в нефтяной промышленности является центробежный насос. При длительной эксплуатации центробежного насоса наблюдается множество отказов. Одной из основных вышедших из строя деталей является крыльчатка. Как известно, неотъемлемой частью функциональности центробежного насоса является его рабочее колесо. Без крыльчатки на поступающую жидкость не может воздействовать центробежная сила. По этой причине выход из строя крыльчатки насоса необходимо было устранить, чтобы исключить выход насоса из строя и обеспечить максимальную продолжительность бесперебойной работы насоса. Основными причинами выхода из строя рабочего колеса являются последствия кавитации, коррозии и эрозии. Здесь рассматривалось покрытие, стойкое к коррозии. Специально для этого в соответствующей лазерной установке ЛД-2000 были подобраны абразивы с различным составом и разработан их технологический режим. В качестве поращка использовались элементы Ni, Cr, Fe, Si, Mo. Зная состав и физико-химические характеристики каждого из этих элементов, был составлен точный протокол технологического режима.
При данном технологическом режиме целесообразно наносить покрытие любой толщины на поверхность рабочих колес. Этот процесс осуществлялся в Лазерном Центре Азербайджанского Государственного Университета Нефти и Промышленности.
Ключевые слова: сплавное покрытие, истирание, коррозионная стойкость и коррозионная стойкость, технологический режим, лазерная установка.

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ANALYSIS OF METHODS FOR INCREASING THE SURVIVABILITY OF SMALL ARMS AND CANNON BARRELS BY THE APPLICATION OF CHROME COATINGS

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ABSTRACT

This paper is an analysis of modern chrome coating technologies for the barrels of small arms and cannons. Barrel survivability refers to the ability of a weapon system to fire a certain number of rounds without significant deterioration in ballistic characteristics. There are various methods to provide the necessary survivability of the barrels, both technological and constructive.
This paper will consider technological methods, in particular chroming technologies.
The objects of the research are various methods of chromium coating: electrolytic, cylindrical magnetron sputtering, galvanic honing, cathode-mechanical chromium plating, and thermodiffusion saturation by chromium.
Electrolytic chrome plating in baths is the most common method, however it has significant drawbacks - toxic waste, difficulty in providing uniformity and integrity of plating, hydrogen release during plating, the need for subsequent heat treatment of the barrel.
Coating barrels with cylindrical magnetron sputtering is one of the least studied methods, but from the available materials we can note the reduced toxicity and the absence of hydrogenation of the barrel and the plating. Nevertheless, the adhesion of the coating material and the barrel should be investigated.
Analysis of the thermodiffusion chrome saturation method is also a promising method. However, a reduction in temperature during the coating process and subsequent normalization of the coating is necessary. This method is currently being investigated in the "Special purpose product technology" laboratory at the Azerbaijan Technical University.
As a result of the research, the most prospective methods can be considered galvanic honing, the cathodic-mechanical method and thermodiffusion chrome saturation. The advantages of these methods are increased productivity and quality of the plating surface. In addition to the prospective chrome plating methods, the paper also noted questions for which the answers remain open.
Keywords: barrel, coating, chromium plating, wear, electroplating, magnetron sputtering, diffusion.

The relevance of the work.
The barrel is an internal combustion engine, where the energy of the propellant gases is used to give a certain speed and direction to the projectile. The barrels of weapon systems work under extreme conditions and during their service, as a result of firing and short-term increases of temperature in the barrel bore up to 2000-3000ºC and pressures up to 700 MPa [1, 2], the barrel bore wear occurs. Bore wear is the result of thermal, chemical and mechanical processes and

depends on many factors - the geometrical parameters of the barrel, physical and chemical parameters of the surface layer of the bore, cartridge parameters and the characteristics of the propellant charge [3]. Eventually, barrel bore wear leads to the deterioration of the ballistic properties of the weapon system or to its complete failure.

Considering the trends in increasing the power of ammunition, the energy intensity of propellant powder, increasing pressure in the barrel and muzzle velocities, both for small arms and for artillery, the question of providing barrels with the necessary survivability arises acutely. One technological method of increasing the service life and survivability of barrels is to apply coatings to the inner surface of the barrel. There are a variety of protective coatings as well as methods of applying them.

Chromium coating is the most common method of improving the wear, corrosion and erosion resistance of barrels. Chromium is a metal with high hardness and good ability to resist mechanical wear. However, high hardness leads to high brittleness and because of this, microcracks may occur in the coating when impact loads are applied. This is the reason why the chrome coating in the area of the barrel's bullet entry is subjected to the most intense damage.

1. Electrolytic chromium plating. Electrolytic chromium plating is the most widespread. As a rule, the technological process of electrolytic chromium plating is similar for different weapon systems. The essence of this method is to pass a direct current through an aqueous solution of metal salts, where the metal atoms are released on the barrel (on the cathode), forming a metallic coating [4].

Figure 1 shows a typical technological process for electrolytic chrome plating for large-caliber barrels. In general, the technological process of electrolytic chrome plating can be divided into three parts: surface cleaning, chrome plating and final stage followed by heat treatment. Heat treatment is conducted to avoid hydrogen embrittlement of chromium [4, 5]. However, this can lead to the destruction of the chromium coating and the appearance of microcracks in the coating.

Electrolytic chrome plating leads to a significant increase in barrel survivability, but it should be noted that the improvements in survivability may vary depending on the caliber, rate of fire and type of ammunition used, regardless of the plating method. A 45% increase in survivability has been recorded for the barrels of large-caliber artillery systems according to [6], and from 2 up to 8-10 times increase for small arms. For instance, the M256 120 mm smoothbore tank gun with M829A2 APFSDS will fire an average of 160-170 rounds, but with chrome plating the survivability is increased up to 500 rounds [7]. However, despite its advantages, electrolytic chromium plating has significant disadvantages: hydrogenation of the barrel and coating material, which leads to increased brittleness; internal stresses; risks to humans and the environment due to the toxicity of hexavalent chromium, which is also the reason for the high cost of disposal [5, 7].

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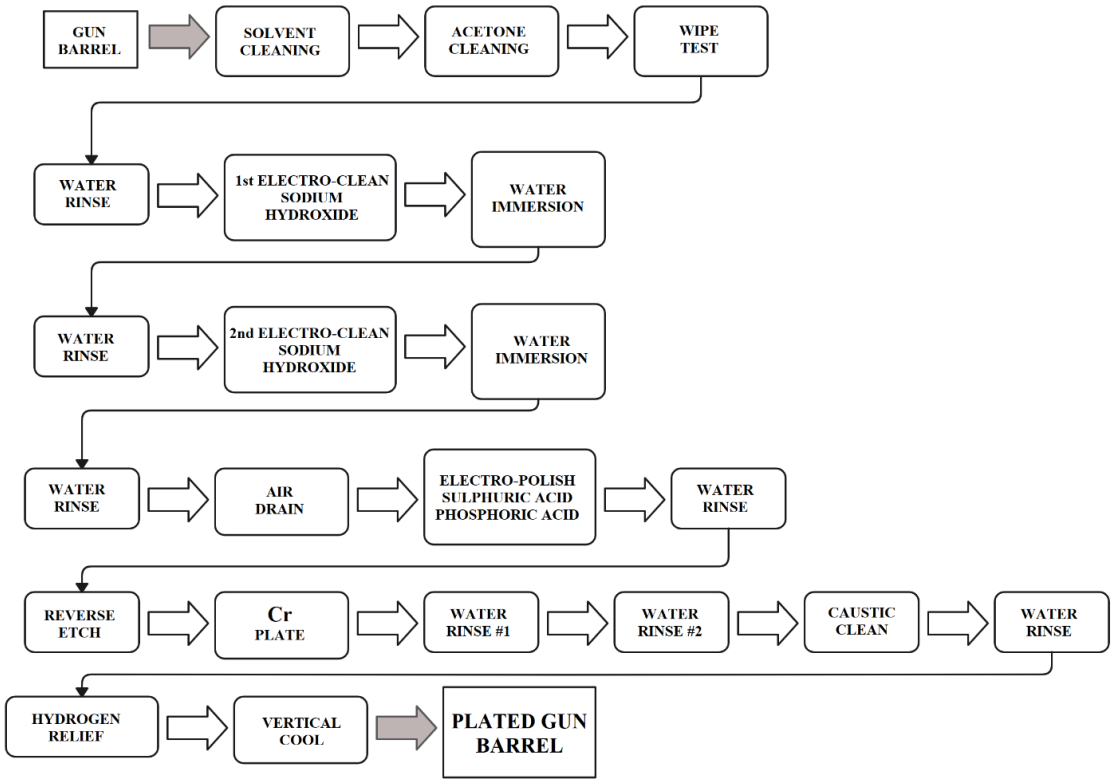

Figure 1: Typical technological process of barrels electroplating [7].

2. Cylindrical magnetron sputtering. This method is a physical vapor deposition process in which the coating material (target) is bombarded with accelerated ions, then evaporated and ejected through a low-pressure vacuum environment to a substrate, on which the material condenses and forms a coating. The advantages of this method are the minimum amount of chemicals in the process, so the method is environmentally friendly, and the low temperatures during the coating process, which does not cause residual stresses in the barrel. However, the main problem with this method can be the adhesion of the coating to the inner surface of the barrel. Also, the inner surface of the barrel must be thoroughly cleaned before the sputtering process. Figure 2 shows the process schematic of a cylindrical magnetron sputtering, using tantalum on the inner surface of a large caliber gun barrel as an example [2].

3. Galvanic honing and cathode-mechanical chromium plating. Galvanic honing and cathode-mechanical chrome plating methods are similar, but have significant differences in technology. The chrome plating process by galvanic honing method consists of a permanent forced correction of the surface formation during the chrome plating process by means of polishing elements. The polishing elements are made from mineral-ceramic. Galvanic honing involves cutting processes in the coating area, so the electrolyte is contaminated by the materials of the cutting tool and the coating.

In cathodic-mechanical method, the correction of the coating surface occurs by sliding the tool over the surface, without cutting processes and, therefore, without electrolyte contamination.

The abrasion resistance of chrome plating achieved by galvanic honing can be 2-4 times higher than that achieved by standard electroplating method [8, 9]. At the same time, this method also

provides higher productivity than electrolytic chromium plating in baths. According to the source [10], productivity can be 50-100 times higher.

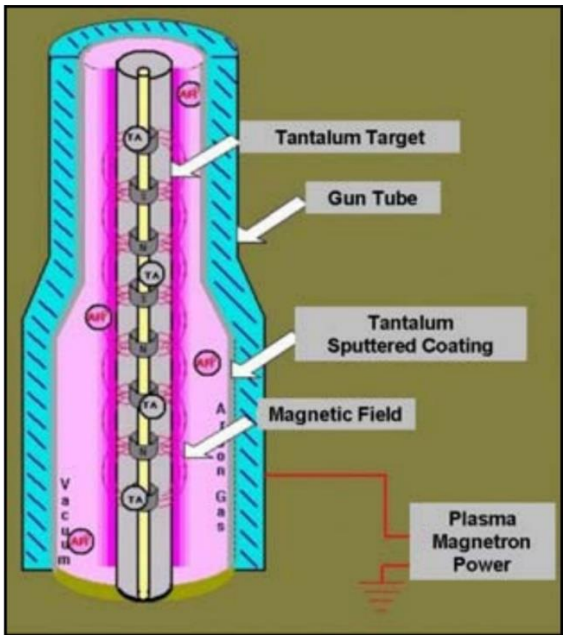

Figure 2: Schematic of a cylindrical tantalum magnetron sputtering process on a large-caliber gun [3].

After firing tests conducted by specialists of the Russian "AO TsNIIM" research institute, no cracks or fractures were found on the surface of the coating [8]. According to the results of the research [8], these methods are considered one of the most promising, allowing to increase the durability of the coating, while increasing the productivity of the technological process.
Figure 3 shows a machine for galvanic honing of cylindrical details.

4. Thermodiffusion saturation by chromium. The method of thermodiffusion saturation means the saturation of the surface layer of a metal with chromium at high temperatures. The barrel and powder mixture are packaged in a container where they are incubated at a certain temperature until the desired coating thickness is obtained. Coating formation is the result of contact between the surface of the product and the particles of the powder environment.
A significant disadvantage of this method is the high temperature during the coating process, which can lead to structural changes in the barrel material as well as the appearance of residual stresses. According to the source [11], the temperature during the coating process can vary from 800 to 1100 ºC, depending on the required coating thickness and substrate material.
According to source [8], South Ural State University specialists conducted a study on powder chromium ERX 99.95-MP grade applied to a 30-mm tube by thermal diffusion plating method. After firing tests, there was heterogeneity in the coating structure, resulting in a large network of cracks in the coating (Figure 4).

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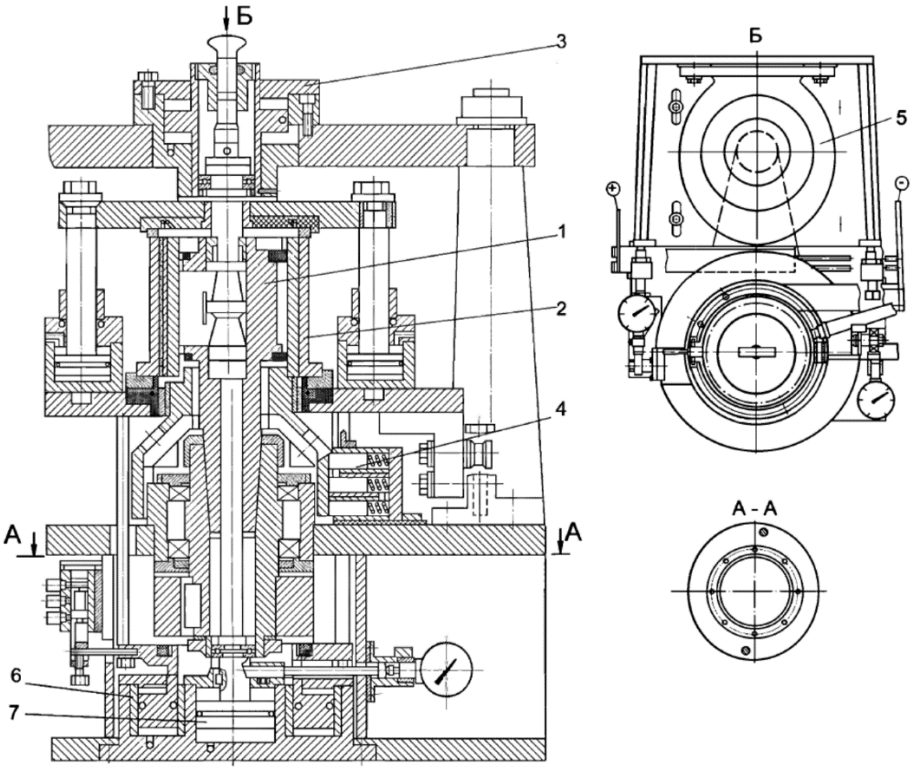

Figure 3: Drawing of a galvanic honing machine [10].

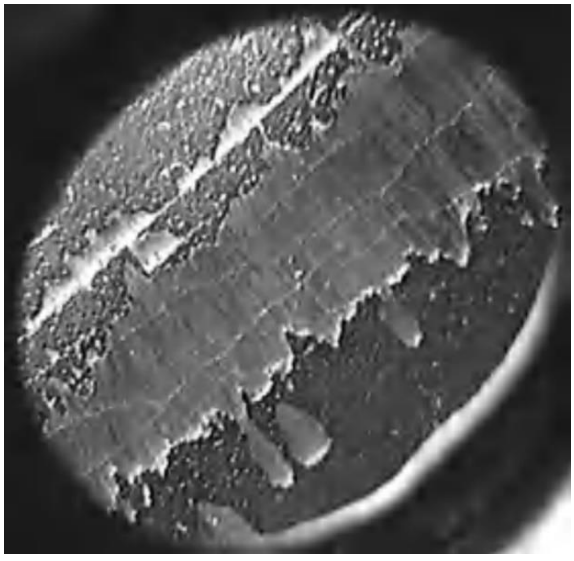

Figure 4: Crack network at the beginning of the barrel tube [8].

However, at Azerbaijan Technical University, the laboratory of «Special purpose products technologies» is conducting research on the coating of special products using the thermodiffusion method. According to research at the Department of Special Technology and Equipment [12, 13],

this method is also promising. To prevent coating failure, the process temperature must be low and normalization of the coating after the saturation process is necessary.

Conclusion.

1. As a result of the analysis, the most promising methods are galvanic honing and cathode-mechanical chromium plating. These methods are superior to electrolytic chromium plating in terms of productivity, as well as in the quality of the resulting coating surface. From which it follows that the barrels coated by these methods will be better both in terms of survivability and in terms of accuracy. However, cylindrical sputtering and thermodiffusion chrome plating technologies should also be further investigated.
2. Despite the above-mentioned advantages, it is also necessary to investigate the cost-effectiveness of these methods as compared to the well-known electrochemical chrome plating method.
3. It is also possible to enhance the already existing method of electrolytic chrome plating in baths, in particular to make hexavalent chrome waste cheaper to dispose of.

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XROM ÖRTÜKLƏRİNİN TƏTBİQİ İLƏ ATICI-TOP SİLAHLARIN LÜLƏLƏRİN UZUN ÖMÜRLÜYÜNÜ ARTIRILMASI ÜSULLARININ TƏHLİLİ

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XÜLASƏ

Məqalə atıcı-top silahların lülələrinin xromlaşdırılması üçün müasir texnologiyaların təhlilindən ibarətdir. Lülənin davamlığı qabiliyyəti silah sisteminin ballistik göstəricilərinni əhəmiyyətli dərəcədə pisləşmədən müəyyən sayda atəş açmaq qabiliyyətidir. Silah sistemlərinin lülələrinin lazımi davamlığı təmin etmək üçün həm texnoloji, həm də konstruktiv müxtəlif üsullar mövcuddur. Bu məqalədə texnoloji üsullar, xüsusən də xrom örtük texnologiyaları araşdırılacaq.
Tədqiqat obyektləri xrom örtüklərin çəkmə üsullarıdır: elektrolitik, silindrik maqnetron püskürtmə, qalvanik honlama, katod-mexaniki üsul və termodiffuziya ilə xromlama.
Elektrolitik xrom örtük ən çox yayılmış üsuldur, lakin onun əhəmiyyətli çatışmazlıqları var - toksik tullantılar, örtükün bütövlüyünü təmin etməkdə çətinlik, örtük zamanı hidrogenin ayrılması, lülənin sonrakı termiki emala ehtiyacı.
Lülələri silindrik maqnetron püskürtmə ilə örtmək ən az öyrənilmiş üsullardan biridir, lakin mövcud materiallardan aşağı toksikliyi və lülənin və örtükün hidrogenləşməsinin olmadığını qeyd edə bilərik. Buna baxmayaraq, örtük materialının və lülənin adheziyası araşdırılmalıdır.
Termodiffuziya ilə örtük çəkmə üsulunun təhlili göstərdi ki, bu üsul da perspektivlidir. Ancaq örtük prosesində temperaturun aşağı salınması, həmçinin örtükün sonrakı normallaşması lazımdır. Bu üsul hazırda Azərbaycan Texniki Universitetinin "Xüsusi təyinatlı məhsulların texnologiyası" laboratoriyasında tədqiq olunur.
Tədqiqat nəticəsində ən perspektivli üsullar qalvanik honlama, katod-mexaniki və termodiffuziya ilə örtük çəkmə üsulu hesab edilə bilər. Bu üsulların üstünlükləri artan səmərəlilik və örtük səthinin keyfiyyətidir. Perspektivli xrom örtük üsullarına əlavə olaraq, məqalədə cavabların açıq qaldığı suallar da qeyd edildi.
Açar sözlər: lülə, örtük çəkmək, xrom örtük, yeyilmə, elektrokaplama, maqnetron püskürtmə, diffuziya.

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АНАЛИЗ МЕТОДОВ ПОВЫШЕНИЯ ЖИВУЧЕСТИ СТВОЛОВ СТРЕЛКОВО-ПУШЕЧНОГО ВООРУЖЕНИЯ ПУТЕМ НАНЕСЕНИЯ ХРОМОВЫХ ПОКРЫТИЙ

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РЕЗЮМЕ

Статья является анализом современных технологий хромирования стволов стрелкового пушечного вооружения (СПВ). Под живучестью ствола подразумевается способность СПВ произвести определенное количество выстрелов без значительных ухудшений баллистических характеристик. Для обеспечения необходимой живучести стволов СПВ существуют различные способы, как технологические, так и конструктивные. В данной статье будут рассматриваться технологические методы, в частотности, технологии покрытия хромом.
Объектами исследования являются различные методы нанесения хрома – электролитический, цилиндрическое магнетронное распыление, гальваническое хонингование, катодно-механический и метод насыщения хромом путем термодиффузии.
Электролитическое хромирование в ваннах является самым распространённым и отработанным методом, однако имеет существенные минусы – токсичность отходов, сложность обеспечения равномерности и целостности покрытия, выделение водорода в процессе хромирования, которая в дальнейшем приводит к повышению хрупкости материала покрытия и ствола, необходимость последующей термообработки ствола.
Нанесение покрытия на стволы СПВ цилиндрическим магнетронным распылением является одним из наименее изученных методов, но по имеющимся материалам можно отметить пониженную токсичность и отсутствие наводораживания ствола и покрытия. Тем не менее, следует изучить вопросы обеспечения адгезии материала покрытия и ствола.
Анализ метода термодиффузионного насыщения хромом также является перспективным методом. Однако необходимо понижение температуры в процессе покрытия, а также последующее нормализация покрытия. Данный метод на данный момент исследуется в лаборатории «технологий изделий специального назначения» в Азербайджанском Техническом Университете.
В результате проведенной работы, наиболее перспективными методами можно считать гальваническое хонингование, катодно-механический метод, а также термодиффузионное хромирование. Преимуществами данных методов являются повышенная производительность и качество поверхности покрытия. Кроме перспективных методов хромирования, в работе также отмечены вопросы, ответы на которые пока остаются открытыми.
Ключевые слова: ствол, покрытие, хромирование, износ, гальваника, магнетронное напыление, диффузия.

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TECHNICAL SOLUTION OF PROBLEMS ARISING ON THE SUCTION AND DISCHARGE VALVES OF THR DRILING PUMP

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ABSTRACT

The purpose of the article is to extend the operational life of piston pumps by making beneficial modifications to the suction and discharge valves. The most common cause of mud pump failures is the wears on the valves so there is an urgent need to increase the durability of the inlet and outlet valves.
This research will allow us to:

- lengthen the functional life of the suction and discharge valves.
- develop the mud pump's technical requirements.
- enhance the drilling pump's economic effectiveness.

Thus, it makes sense to do study on piston mud pump valves in order to improve the technical parameters by making some positive adjustments. A moved forward valve situates which essentially diminishes the affect stretch caused by the effect of a piston pump valve body contrary the valve situates. The valve situate comprises a by and large round and hollow body parcel portion parcel with a fixing surface which is slanted from the external surface of the round and hollow body parcel toward an insides throat of said round and hollow body parcel. The valve body comprises a for the most part disc-shaped parcel and a truncated funnel shaped parcel. An elastomer embed is gotten in a groove within the valve body. The cone shaped parcel of the valve comprises an inclined confront, counting a metal parcel and an elastomeric parcel shaped by the elastomeric embed. Within the valve situate of the present innovation, an annular weight alleviation groove within the round and hollow body parcel of the valve situate permits the inclined confront of the valve situate to flex subsequently calming a noteworthy sum of the affect stack between the restricting confront of the valve gathering.
Keywords: suction valve, discharge valve, valve wears, valve seat, poppet valve, piston mud pumps.

Operability of a mud pump is generally characterized by its fluid end parts: pistons, direct bushings, valves, pressing. Beneath extraordinary operation conditions, the operational life of the liquid end components may sum to as it were a few handfuls of hours. (Figure 1)

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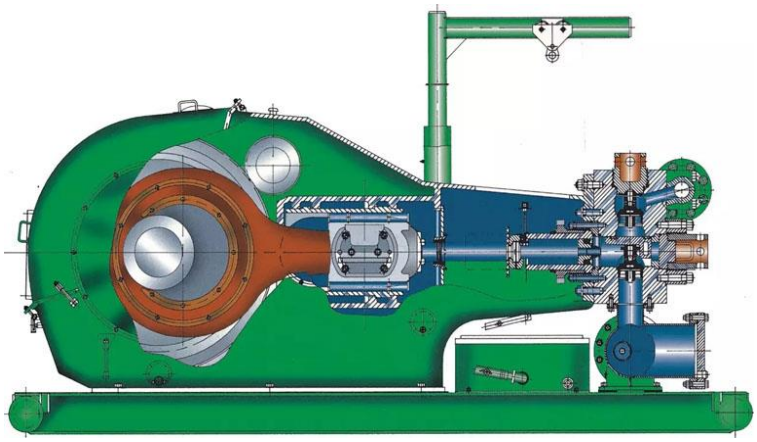

Figure 1: Constructive view of piston mud pump.

One of imperative liquid end components of a pump is its valve. In this way, settling issues in progressing the operational life of the pump components, as we entirety, may be a convenient issue. Objective of investigate is to progress operational proficiency of piston mud pumps by moving forward the design of reverse valves by lessening dynamic loads happening as a result of affect between the poppet and the valve seat. As of now, at the side necessities for primary operational parameters, financial proficiency and long operational life, piston pumps are subjected to extra necessities for low noise and vibration levels. One of vibration sources within the fluid end of a cylinder pump is its valve parts, whose expanded vibration leads to untimely wear, as well as to disappointment of pump components. To determine most extreme loads transferred to the pump lodging and their wavering frequencies after the poppet touches the seat, a few researches inquire about has been conducted. Explanatory demonstrate and conditions modeling operation of a valve are given in Figure 2.

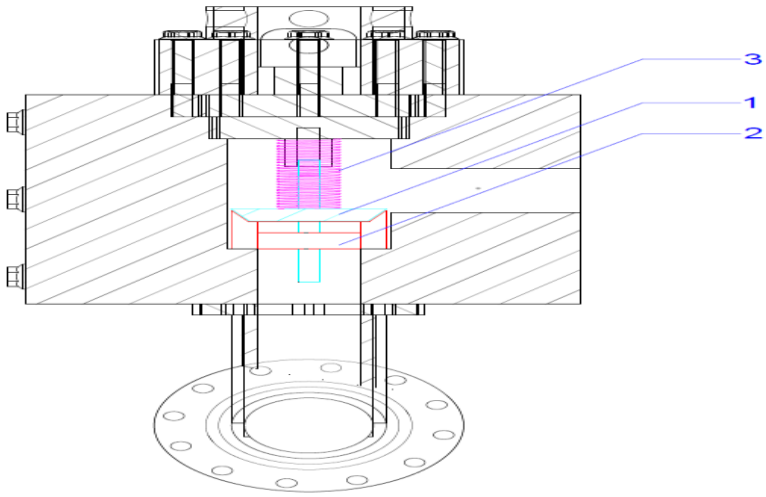

Figure 2: Analytical model for modeling mud pump valve operation.
1 – poppet; 2 – valve seat; 3 – spring.

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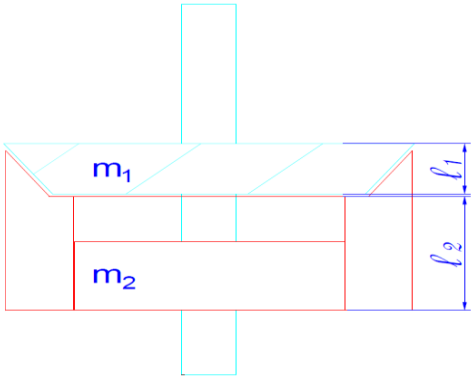

Figure 3: The equation for the loading of surfaces at the moment of contact

$$m_1 x''_1 = - c_1(x_1 - x_2) - \mu(x'_1 - x'_2) \quad (1)$$

$$(m_1 + m_2)x''_2 = -c_2 x_2 + c_1(x_1 - x_2) - \mu x'_2 + \mu(x'_1 - x'_2) \quad (2)$$

In given equations:
m_1, m_2 – stem weights;
x_1, x_2 – coordinates;
x'_1, x'_2 – velocities;
x''_1, x''_2 – accelerations;
μ – drag coefficient;
c_1, c_2 – stiffness coefficients of stems;
l_1, l_2 – stem lengths:
To diminish the forces transferred to the pump lodging amid the seating, we propose introducing a special component made of versatile fabric between the seat and the pump lodging. Concurring to the hypothetical information, an unused valve design has been created. Compared to the current form, shapes of seating surfaces of the poppet, the situate and the pressing ring has been changed. The seating surface of the situate is made within the frame of a cone, transitioning to cylinder. The poppet includes a shape of a cone shaped disk and when situated it bears against the round and hollow surface along the elastic pressing ring, in this way permitting decrease of affect between the poppet and the situate and giving valve snugness.
The investigate uncovered, that the proposed valve plan permits diminishing the effect of the poppet and the situate and gives valve snugness, be that as it may, vibration recurrence of the lodging increments. Nearness of a streaming fluid layer work out a damping impact, which within the conclusion leads to presence of low frequency shakes. Due to that, the moment variation of the mud pump valve has been created. To hose the vibration and diminish loads transferred to the pump lodging from the affect between the poppet and the situate, we propose to introduce extraordinary versatile component made of flexible fabric between the situate and the pump lodging. On the one hand, this component might work as a spring, diminishing the size of loads transferred to the pump lodging and serving as a vibration isolator, and on the other hand, it'll

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hose the motions. Modeling graph of valve operation with flexible component between situate and pump lodging, as well as pertinent differential conditions are appeared in below.

$$m1x''1 = -c1(x1 - x2) - \mu(x'1 - x'2) \quad (3)$$

$$(nm1 + m1)x''2 = -\frac{c1}{n}(x1 - x3) + c1(x1 - x2) - \mu(x'2 - x'3) + \mu(x'1 - x'2) \quad (4)$$

$$\frac{n2m1}{\rho1/\rho2} + nm1)x''3 = -\frac{c1}{n2(E1/E2)}x3 + \frac{c1}{n}(x2 - x3) - \mu3x'3 + \mu(x'2 - x'3) \quad (5)$$

In given equations:
ρ_1, ρ_2 - density values of the poppet and the versatile component separately;
l_3 – height of versatile component;
E_1, E_3 - Young's modulus of the poppet and the versatile component separately;
X_3 – coordinate;
x'_3, – velocity;
x''_3, – acceleration;
$n = \frac{c2}{c1}$;
$n2 = \frac{l3}{l1}$;
Arrangement of the given differential conditions has appeared that the nearness of the flexible component between the valve situate and the pump lodging permit decreasing the loads of the exchanged loads and wavering frequencies by an arrange of size.
The valve drawing with a flexible component within the shape of a thick washer introduced between the valve situate and the pump lodging is appeared in Figure 3.

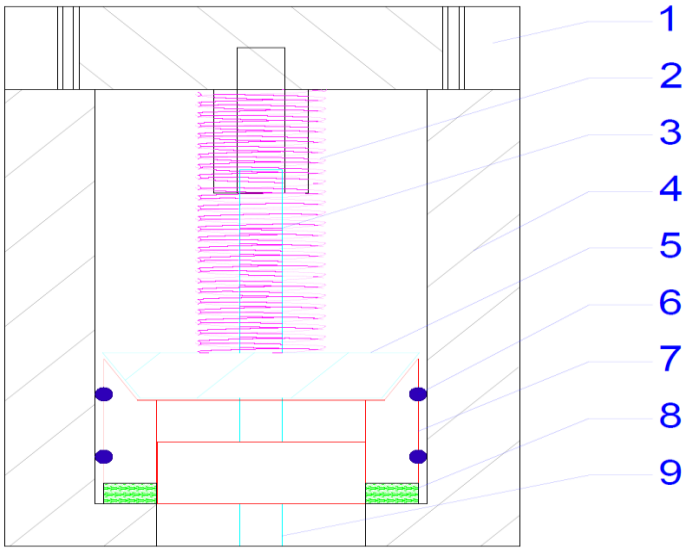

Figure 3: Modified valve drawing with flexible element.
1 – valve cover; 2 – spring; 3 – limiter; 4 – housing; 5 – poppet; 6 – seals; 7 – seat; 8 – elastic element; 9 – spigot:

Amid the operation, an affect wave emerging from seating the poppet to the situate is transferred to the flexible component that serves as a spring. Due to minimum inflexibility of the component, vibration of the pump lodging is diminished and as a result, operational productivity of the pump as an entirety progresses. Testing of the created valve at the test stand affirmed a critical decrease in vibration recurrence and affect loads.

CONCLUSION:

The comes about of the investigate:

1. Most extreme esteem of loads and their frequencies transferred from the valve to the pump lodging depend on the esteem of the modulus of flexibility of the valve component materials. When the proportion between Young's versatility values of the poppet and the flexible component is higher than 100, greatest loads transferred to the pump lodging decrease altogether. 2. A specialized arrangement is proposed, permitting diminishing the values of the loads exchanged to the pump lodging when the poppet is situated to the valve situate.
3. Exploratory investigate performed at the uncommonly created test stand has appeared, that increment within the swaying frequencies permits decreasing most extreme plentiful of vibration on normal by 16% compared to the plentiful of mass-produced valves.
4. The exploratory investigate of the created valve with changes in plan permitted setting up that a shock-free seating of poppet to the situate is accomplished and generally operational effectiveness of the mud pump increments.

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ТЕХНИЧЕСКОЕ РЕШЕНИЕ ПРОБЛЕМ ВОЗНИКАЮЩИЕ НА ВЫСАСЫВЮЩИЙ И НАГНИТАТЕЛЬНЫЙ КЛАПАНА БУРОВОГО НАСОСА

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РЕЗЮМЕ

Ель статьи - продлить срок службы поршневых насосов путем внесения полезных изменений во всасывающие и нагнетательные клапаны. Наиболее распространенной причиной отказов грязевых насосов является износ клапанов, поэтому существует острая необходимость в повышении долговечности впускных и выпускных клапанов.
Данное исследование позволит нам:
- продлить срок службы всасывающих и нагнетательных клапанов.
- разработать технические требования к буровому насосу.
- повысить экономическую эффективность бурового насоса.
Таким образом, имеет смысл провести исследование клапанов поршневых грязевых насосов с целью улучшения технических параметров путем внесения некоторых положительных корректировок. Сдвинутая вперед посадочная площадка клапана, которая по существу уменьшает растяжение, вызванное воздействием корпуса клапана поршневого насоса на посадочную площадку клапана. Ситуация клапана включает в себя по большому счету круглую и полую часть корпуса с фиксирующей поверхностью, которая наклонена от внешней поверхности круглой и полой части корпуса к внутреннему горлу этой круглой и полой части корпуса. Корпус клапана включает в себя по большей части дискообразную часть и усеченную воронкообразную часть. В канавку в корпусе клапана вставлен эластомер. Конусообразная часть клапана включает в себя наклонный фронт, считая металлическую часть и эластомерную часть, сформированную эластомерной вставкой. В клапане настоящего изобретения кольцевая канавка для уменьшения веса в круглом и полом корпусе клапана позволяет наклонному фронту клапана изгибаться, что впоследствии успокаивает значительную сумму аффекта между ограничительными фронтами клапана.
Ключевые слова: всасывающий клапан, нагнетательный клапан, износ клапана, седло клапана, тарельчатый клапан, поршневые буровые насосы.

QAZMA NASOSUNUN SOVURMA VƏ VURMA KLAPANLARINDA YARANAN PROBLEMLƏRİN TEXNİKİ HƏLLİ

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XÜLASƏ

Məqalənin məqsədi sorma və vurma klapanlarına faydalı dəyişikliklər etməklə pistonlu nasosların istismar müddətini uzatmaqdır. Qazma nasoslarında meydana gələn nasazlıqların böyük əksəriyyətinin səbəbi klapanların aşınmasıdır, buna görə də giriş və çıxış klapanlarının davamlılığının artırılmasına ehtiyac var.

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Bu araşdırma bizə imkan verəcək:
- sorma və vurma klapanlarının istismar müddətini uzatmaq.
- qazma nasosunun texniki parametrlərini yüksəltmək.
- qazma nasosunun iqtisadi səmərəliliyini artırmaq.

Nəticə olaraq, inkişaf yönümlü dəyişikliklər edərək pistonlu qazma nasosu klapanlarının texniki parametrlərini yüksəltmək üçün araşdırma aparmaq məqsədəuyğundur.

Qazma nasosu klapan gövdəsinin klapan oturacağına vurduğu zərbə nəticəsində yaranan zərbə gərginliyini əhəmiyyətli dərəcədə azaltmaq məqsədi ilə təkmilləşdirilmiş klapan oturacağı ilə təmin olunması müsbət nəticə göstərə bilər. Klapanın oturacağı silindrik gövdə hissəsinin xarici səthindən sözügedən silindrik gövdə hissəsinin daxili boğazına doğru maili olan möhürləyici səthi olan, ümumiyyətlə silindrik gövdə hissəsindən ibarətdir. Valf gövdəsi ümumiyyətlə disk formalı hissədən və kəsilmiş konusvari hissədən ibarətdir. Valf gövdəsindəki yivdə bir elastomer əlavə olunur. Klapanın konusvari hissəsi maili üzdən, o cümlədən metal hissədən və elastomerik əlavə ilə yaradılmış elastomer hissədən ibarətdir. Bu ixtiranın klapan oturacağında, klapan oturacağının silindrik gövdə hissəsindəki həlqəvari təzyiq tənzimləyici yiv klapan oturacağının maili üzünün əyilməsinə imkan verir və bununla da klapan qurğusunun əks üzü arasında təsir yükünün əhəmiyyətli bir hissəsini azad edir.

Açar sözlər: sorma klapanı, boşaltma klapanı, klapan aşınması, klapan oturacağı, klapan, porşenli qazma nasosları.

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REINFORCEMENT OF PISTON PUMP BORE SURFACES WITH NANO PARTICLES AND INCREASE OF CORROSION RESISTANCE

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ABSTRACT

Oilfield pumps occupy a special place in the structure of the complex of equipment used in the drilling of oil and gas wells. It is established that the plunger-bushing assembly is the most vulnerable pair and the failure rate of the pump is largely determined by the failure of this particular node. In order to improve the efficiency and service life of the pump, it is proposed to process the inner surface of the bushings on a laser installation with Cu, Fe, Al nanoparticles. Based on numerous experimental studies, the optimal number of nanoparticles and the technological mode of their application are proposed. It is established that with a decrease in the size of nanoparticles, the hardness of the hardening surface increases many times. This can be explained by the fact that the deformation of the material is caused by the movement of dislocations, while its intergranular boundaries act as a surface against the movement of dislocations.
Keywords: Plunger-bushing pair, nanoparticle, deformation, surface hardening.

INTRODUCTION

A large part of the pumps used in the drilling and operation of oil wells are piston pumps. In these pumps, the hydraulic nodes fail in a short time, reducing the reliability and longevity of the device. [1]

Conducted studies show that piston-cylinder pairs often fail. In order to determine failures in piston-cylinder pairs, they study operating conditions in depth and analyze the reasons for failure. The piston-cylinder pair is affected by the compression line pressure, the properties of the injected fluid, including the types of oil and gas, their temperature, abrasive particles in the sand and clay, and the corrosive environment. It should be noted that the formation of lines, scrapes, abrasions and tears was observed on the surfaces of the groove piston bore in the piston-cylinder pair due to the effect of abrasive particles.

The materials of the bores made in many factories are steel-45, steel-40 and steel-70, and by conducting thermal processes with high-frequency current on their inner surfaces, they increase strength and wearing durability. In addition, the conducted tests show that by applying boron, nickel, cast iron (2.9%C, 1.8%B, 3.7% Ni, 10%Mn, 0.8%Si) to the surface of the cylinder bore, they increase its corrosion resistance and strength.[1,2]

Despite this, various types of corrosion and other defects are still observed on the surfaces of the cylinder bore. In order to prevent them, the technology of making the carving, the coating, and the operating conditions must be taken into account. The processes observed in the scientific works of M.M. Khrushov, I.V. Kragellsin, and S.H. Babayev have been fully investigated. Information

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about the scientific-research works related to increasing the strength and corrosion resistance of cylinder carving is given in the literature [3].

Table 1: Corrosion characteristics of cylindrical bores

Types of wearing	The path of friction, mm	Wearing in cross-section along the axis, mm	Depth of wearing along the cross-section, mm	Number of ruptures along the cross-section, m^{-1}
Abrasive	12,82	180	125	49
Hydroabrasive	18,94	250	234	58
Erosion	21,22	380	286	64
Erosion-corrosion	31,46	425	322	82

Structure of the issue

Recently, the research conducted by V.S. Lomakin and V.A. Peshman shows that it is appropriate to use coatings to increase the strength and durability of cylinder bore. Unlike the above-mentioned methods, no additional technological processes are required for coating. Taking these into account, it is possible to obtain a highly cost-effective and high-quality coating from the type of technological process.

As a result of the analysis of oil-field indicators, the directions of failures on the surfaces of the piston-cylinder pair are as follows:

1.Wearing of the cylinder bore along the diameter.

2. Oymağın işçi səthlərində uzununa cizik və yeyilmə izlərinin müəyyən dərinlikdə olması.

3. Cracks and breaks are observed on the working surfaces of the cylinder bore.

In order to eliminate these indicated defects, the following studies should be carried out to apply a nano coating on the surface of the bore:

- selection of nano-coating on the surface of the cylinder cavity and determination of its parameters;
- studies of the corrosion process in the nano coating of cylinder bore;
- studies of strength, hardness and wearing resistance in nano-coatings.

Theoretical studies.

It is considered important to obtain a layer (coating) of Cu, Fe, Al - nano material elements in the form of a coating by sputtering on the inner surfaces of the carving.

The oxides of these elements were used to obtain nano powder particles in a vacuum. Since these nanoparticles are obtained in different nano sizes, it should be studied separately.

The mechanical properties of the material can be viewed as a summary of the properties of polycrystals consisting of arbitrarily oriented single crystals. It is believed that the mechanical properties of a compact material are primarily related to large-angle boundaries and arbitrary orientation of grains. By the same rule, in a monostructured material, it can be viewed as a collection of very small-nanosized particles (crystals) separated from each other by large angular boundaries. Referring to this consideration, it can be assumed that the mechanical properties and behavior under load of nano or compact materials should be of the same nature. However, this possibility is true only up to a certain size of the grains.

Table 2 shows the composition of different brands of aluminum-based nanocoatings. [3]

Table 2: Chemical composition of aluminum-based nano coatings, %

Coating mark	Si	Fe	Mn	Mg	Zn	Al
AA6060	0,45	0,2	-	0,5	-	Balance
AA6082	1,0	0,3	0,7	0,9	-	Balance
AA3003	0,5	0,5	1,3	-	-	Balance
AA5182	0,1	0,2	0,4	4,5	-	Balance
AA5745	0,3	0,2	0,4	3,2	-	Balance
AA6061	1,25	0,3	-	0,5	-	Balance
AA7072	0,2	0,3	0,3	1,2	4,5	Balance

It is considered more appropriate to apply these nanoparticles to the inner surfaces of the carving by heating them at a temperature of 400-600 ^{0}C. These temperatures are the maximum temperatures that occur in the bore-piston pair. Cylindrical bores mainly steel 40X, 20X; 45 and are made of cast iron. Therefore, it is assumed that these nano-elements will be deposited on the inner surface of the engraving in a 10-100 nm thick layer within a specified period of time.

Obtained results and their analysis.

One of the main mechanical properties of a material is hardness. Studies show that the hardness of the material is determined by the Hall-Petch law, depending on the *HB* hardness of the grain. Therefore:

$$HB=HB_0+Kd^{-1/2}$$

Here H_0 is grain hardness (Pa); K – loss coefficient (1.2÷1.4); d - is the grain size (nm).

According to the above dependence, the reduction of the grain size should lead to an increase in the hardness and strengthening of the material. Indeed, the hardness of nanomaterials at room temperature is 2-7 times higher than that of compact material. This can be explained by the fact that the deformation of the material is related to the movement of dislocations, and the grain boundaries act as a surface against the movement of dislocations.[4]

The hardness of the nanomaterial coating is determined by the Hall-Petch law:

$$HB=HB_0+Kd^{-1/2}$$

$HB_{Al}=27+\frac{1.2}{\sqrt{10\cdot10^{9}}}=27+12000=12027$ – For aluminum-containing nano coating.

$HB_{Fe}=82+\frac{1.4}{\sqrt{10\cdot10^{9}}}=82+14000=14082$ – For iron-containing nano coating.

$HB_{Cu}=80+\frac{1.3}{\sqrt{10\cdot10^{9}}}=80+13000=13080$ – For copper-containing nano coating.

In this study, 10, 20, 40, 60, 80 nm values were studied.

Hardnesses accordingly:

For Al:

HB_1=12027; HB_2=8512,28; HB_3=6027; HB_4=4925,97; HB_5= 4269,64

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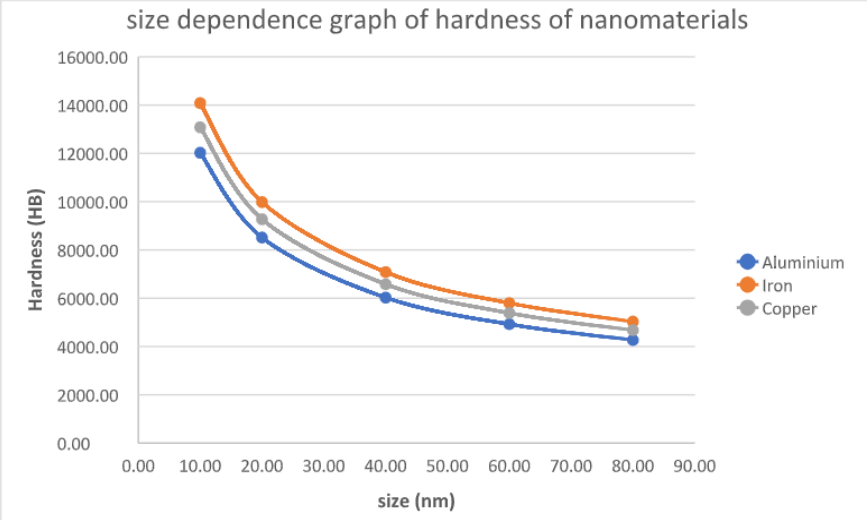
For Fe:
HB_1=14082; HB_2= 9981,49; HB_3= 7082; HB_4= 5797,47; HB_5= 5031,74
Cu üçün:
HB_1= 13080; HB_2= 9272,38; HB_3= 6580; HB_4= 5387,22; HB_5= 4676,19
At the same time, the value of the friction coefficient is calculated by the known formula:

$$f_s=\frac{\tau}{HB}+\beta$$

$f_s=\frac{250}{12027}+1,1$=1,1207 – For Aluminium
$f_s=\frac{250}{14082}+1,3$=1,3177 – For Iron
$f_s=\frac{250}{13080}+1,2$=1,2191 – For Copper
Analogously, the friction intensity parameters can be approximately determined:

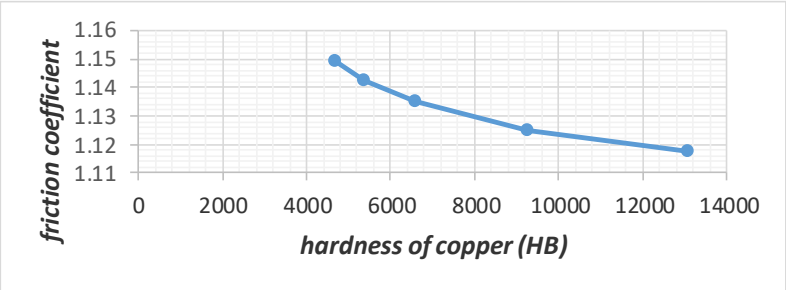
$$J_h=K\frac{\rho}{HB^2}$$

The dependence of the hardness on the nanoparticle size for Fe, Al and Cu according to the report carried out with the given formulas is presented (graph 1).
Graph 1.

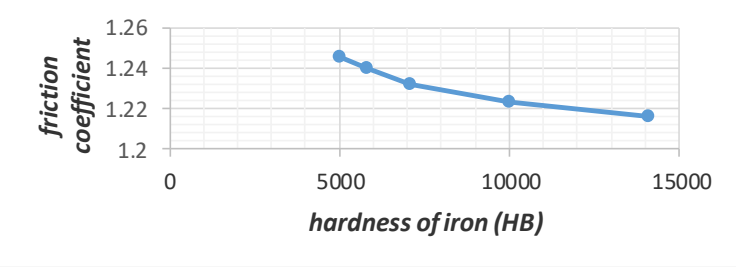


At the same time, a graph of the dependence of the friction coefficient on the hardness of each type of nanomaterial is presented (graph 2, 3, 4).

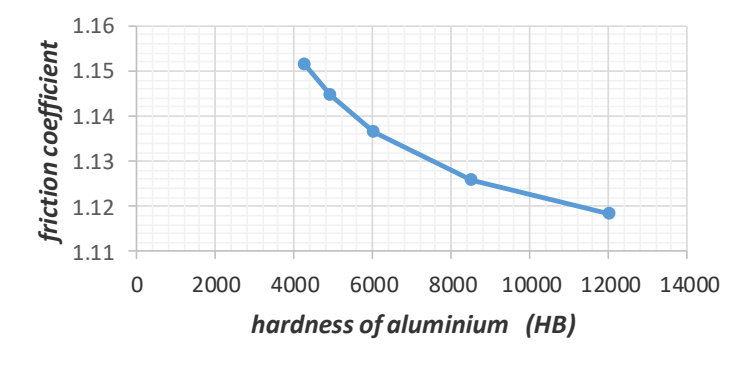
Graph 2.



Graph 3.



Graph 4.



Result

The technological mode of coating by means of nano-coating was developed by analyzing the increase of the stiffness of the piston pump joint. With this nano-coating, it is possible to increase the corrosion resistance of the carving by 4-10 times.

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NANO HİSSƏCİKLƏRLƏ PİSTONLU NASOSUN OYMAĞININ SƏTHLƏRİNİN MÖHKƏMLƏNDİRİLMƏSİ VƏ YEYİLMƏYƏ DAVAMLIĞININ ARTIRILMASI

Nazim İbrahimov[1], Məhəmməd Rüstəmov[2]
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XÜLASƏ

Neftmədən nasosları neft və qaz quyularının qazılması prosesində istifadə olunan avadanlıq kompleksinin strukturunda xüsusi yer tutur. Plunjer-oymaq cütlüyü nasos qurğusunun ən həssas cütlüyü hesab olunur və nasosun etibarlığı və uzzun ömürlüyü məhz bu düyünündə baş verən imtinaların sayı ilə sıx əlaqəlidir. Nasosun səmərəliliyini və ehtiyatını artırmaq üçün onun oymağının işçi səthlərini Cu, Fe, Al nanohissəciklərlə lazer qurğusundakı emal etmət təklif olunur. Çoxsaylı eksperimental tədqiqatlar əsasında nanohissəciklərin optimal sayı və onların tətbiqinin texnoloji rejimi təklif olunur. Nanohissəciklərin ölçüsünün azalması ilə işçi səthin bərkliyinin dəfələrlə artdığı müəyyən edilmişdir. Bu, materialın deformasiyasının dislokasiyaların hərəkəti ilə əlaqəli olması, onun fazalararası sərhədlərin dislokasiyaların hərəkətinə qarşı bir səth kimi çıxış etməsi ilə izah olunur.
Açar sözlər. Plunjer-oymaq cütlüyü, nanohissəcik, deformasiya, səthin emalı, bərklik.

УСИЛЕНИЕ ВНУТРЕННИХ ПОВЕРХНОСТЕЙ ПОРШНЕВЫХ НАСОСОВ НАНОЧАСТИЦАМИ И ПОВЫШЕНИЕ КОРРОЗИОННОЙ СТОЙКОСТИ

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РЕЗЮМЕ

Нефтепромысловые насосы занимают особое место в структуре комплекса оборудований используемые в процессе бурения нефтяных и газовых скважин. Установлено, что узел плунжер- втулка является наиболее уязвимой парой и частота отказов насоса во многом определяется выходом из строя именно этого узла. С целью повышения работоспособности и ресурса насоса предлагается провести обработку внутренней поверхности втулок на лазерной установки с наночастицами Cu, Fe, Al. На основании многочисленных экспериментальных исследований предлагается оптимальное количество наночастиц и технологический режим их нанесения. Установлено, что с уменьшением размера наночастиц твердость поверхности упрочнения многократно увеличивается. Это объяснить тем, что деформация материала обусловлена движением дислокаций, в то время как его межзерновые границы выступают в качестве поверхности против движения дислокаций.
Ключевые слова: Плунжер-втулочная пара, наночастица, деформация, упрочнения поверхности.

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$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right) \quad (1)$$

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This section may each be divided by subheadings or may be combined. A combined Results and Discussion section is often appropriate. This should explore the significance of the results of the work, don't repeat them. Avoid extensive citations and discussion of published literature only, instead discuss recent literature for comparing your work to highlight novelty of the work in view of recent development and challenges in the field.

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Layout	**Size**	**Margin (Normal)**	Header	Footer	
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Font	**Article Title**	**Headings**	**Subheadings**	**Reference list**	**Text**
	Times New Roman, 16 pt, Bold, centred	Times New Roman, 11 pt, Bold, Left aligned	Times New Roman, 10 pt, Bold, Left aligned	Times New Roman, 8 pt, Justified	Garamond, 11 pt, Justified
Line Spacing	1.15	1.15	1.15	1.15	1.15
Page number	We will format and assign page numbers				

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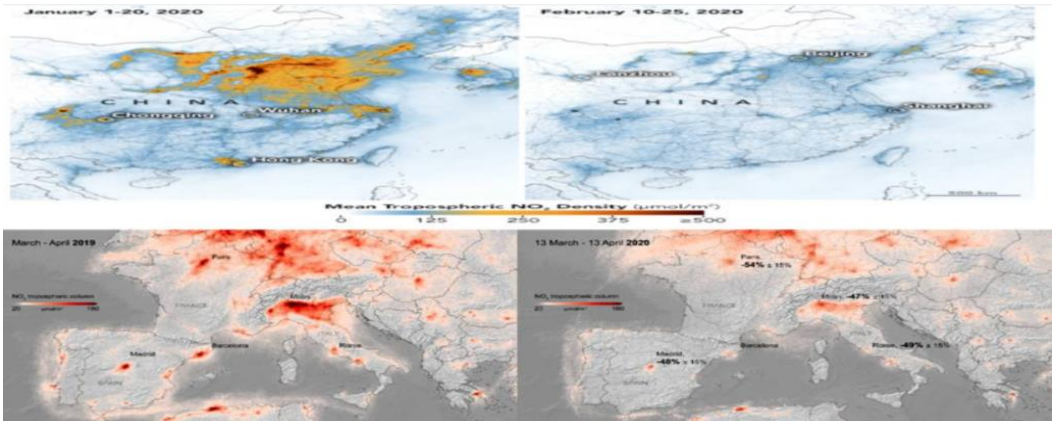

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2. Bahishti, “Peer Review; Critical Process of a Scholarly Publication”, J. Mod. Mater., vol. 2, no. 1, pp. 1.1-1.2, Oct. 2016. https://doi.org/10.21467/jmm.2.1.1.1-1.2
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4. W. S. Author, “Title of paper,” Name of Journal in italic, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year. Access online on 20 March 2018 at https://www.aijr.in/journal-list/advanced-journal-graduate-research/
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Ключевые слова: Авторам рекомендуется указывать 3-5 ключевых слов, относящихся к статье, через запятую. Эти ключевые слова будут использоваться для целей индексации.

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